Planning for Climate Change

Integrating Climate Mitigation & Adaptation into the Comprehensive Plan for the City of Snohomish

Final Report

June 7, 2023

Prepared for the City of Snohomish

Keala Aronowitz
Matthew Bauman
Scott Brabec
Carson Bridges
Neha Chinwalla
William Feeney
Maren Grunnet
Amy Miller
Caroline Passalacqua
Catherine Schmidt
Tim Seed
Sarah Udelhofen

University of Washington
College of Built Environments
Department of Urban Design & Planning

Table of Contents

Table of Contents......1

Executive Summary......2

White Paper: Climate Resilience in Focus: Enhancing Snohomish's Comprehensive Plan......3

Section 1: Greenhouse Gas Emissions Analysis for the City of Snohomish...... 8
Section 2: Existing Climate Impacts for the City of Snohomish...... 20
Section 3: Climate Projections for the City of Snohomish...... 38
Section 4: SWOT Analysis of Climate Change Driven Risks to Assets......43
Section 5: Climate Change Regulatory Framework for the City of Snohomish......48
Section 6: Environmental Protection Element Gap Analysis......57
Section 7: Draft Goals and Policies for Climate and Environment Element......68
Section 8: Carbon Sinks Identification & Storage Inventory...... 71

Methods...... 80
Section 1 Methods: ICLEI GHG Scope 2 Community Inventory...... 80
Section 2 Methods: Existing Impacts Analysis......83
Section 3 Methods: Climate Projections for the City of Snohomish......90
Section 4 Methods: SWOT Analysis Related to Climate Protection......92
Section 5 Methods: Climate Change Regulatory Framework for the City of Snohomish...... 94
Section 6 Methods: Snohomish Comprehensive Plan: Environmental Protection Element Gap Analysis......96
Section 7 Methods: Draft Goals and Policies for Climate Element......97
Section 8 Methods: Carbon Sinks Identification & Storage Inventory......100

Works Cited...... 104

Appendices...... 111
Appendix A: 2022 City of Snohomish GHG Inventory Data...... 111
Appendix B: Snohomish Climate Projections......111
Appendix C: Risk Matrix for the City of Snohomish......111
Appendix D: Regulation Summaries...... 111
Appendix E: Snohomish County Hazard Mitigation Plan Climate Change Summary......111
Appendix F: Comprehensive Policy Menu...... 111
Appendix G: Tailored Policy Menu......111
Appendix H: Climate Resilience Advisory Board Meeting Summary...... 111

Executive Summary

This report is the compilation of the work performed by the Snohomish Climate Planning Studio, a two-quarter Master of Urban Planning course at the University of Washington. The studio partnered with the City of Snohomish through the University's Livable City Year Program from January to June of 2023, providing the opportunity for students to assist the City in its effort to incorporate climate change into the Environmental Protection element of the Comprehensive Plan, which will be renamed the Climate and Environment Element in the 2024 update.

The project began in the Winter 2023 quarter, with students becoming familiar with the City of Snohomish, including its population and demographics, capital facilities and community context, land uses and economy, all considered through the lens of climate change. This research, presented to City staff and stakeholders in March 2023, became the foundation for our work in the Spring 2023 quarter, during which we produced the work included in Sections 1-8 of this report.

The passage of the State of Washington's Climate and Commitment Act of 2021, and subsequent House Bill 1181 in the spring of 2023, have made integrating climate planning into the Comprehensive Plan a high priority. Communities are required to identify how they will plan for climate mitigation, or the reduction of current greenhouse gas (GHG) emissions, and climate adaptation, which involves anticipating and reducing negative climate change impacts that are already evident. To address these requirements, we conducted a greenhouse gas inventory to identify where Snohomish generates the most emissions, which informed a greenhouse gas reduction goal and policy recommendations. The use of natural gas for residential heating and cooking accounts for almost half of the City's emissions. Policies that reduce natural gas dependency will therefore be critical for the City to significantly reduce annual emissions.

Increased flooding, more frequent extreme heat events, and exposure to wildfire smoke are expected to pose the most risk to Snohomish and its residents in coming years. These events will most acutely impact Snohomish's vulnerable populations, which include (though are not limited to) children, the elderly, low-income individuals, people with disabilities, and people with pre-existing health conditions. We used this knowledge to identify the potential risk to key City assets due to climate-exacerbated events, which then informed policy recommendations. Our policy recommendations also considered the results of a gap analysis of the current Comprehensive Plan and a review of county, regional, and state regulations and policies related to climate planning, which revealed potential areas for improvement. Policies that will be most impactful in Snohomish are those that reduce GHG emissions, promote localized adaptation to climate hazards like flooding, integrate equity and environmental justice, and consider co-benefits of individual policies to enhance overall effect.

We are grateful for the opportunity to collaborate with the City of Snohomish on this effort, and are encouraged to see the steps that the community is taking to be proactive in the face of climate change.

Climate Resilience in Focus: Enhancing Snohomish's Comprehensive Plan

White Paper Outlining Climate Planning Integration

Introduction

The City of Snohomish has partnered with the University of Washington's Livable City Year (LCY) program to assist with the Comprehensive Plan Periodic Update. The passage of the State of Washington's Climate and Commitment Act of 2021, and subsequently House Bill 1181 in the spring of 2023, has made integrating climate planning into local Comprehensive Plans a high priority. As University of Washington Master of Urban Planning students, the focus of our studio is to provide recommendations for the Environmental Protection element of the plan, which will be renamed the Climate and Environment element.

We began by learning about the City of Snohomish; its resources and population, capital facilities and community context, land uses and economy, all examined through the lens of climate change. We toured portions of Snohomish with City staff to further understand the community and the physical and economic environs. At the end of the first phase of our climate planning studio, we presented our progress and findings to select City staff to receive feedback as to where to focus our efforts for the next phase.

For this final phase, we have been conducting analysis to better understand the effects that climate change is anticipated to have on the City and its residents while immersing ourselves in expert guidance on how best to address climate change in comprehensive plans. This section of the report is a summary and very high-level view of our findings.

Presentations and Feedback

Throughout the project, we benefited from direct feedback from City staff and community members to inform and guide the next steps of the inquiry. In April, we presented progress to date to City representatives[1] on the analysis of existing impacts, climate projections, priority hazards, and the SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis and received helpful feedback and considerations. In May, we were invited to Snohomish to present to the Climate Resilience Advisory Board (CRAB), a group of community members convened to provide advisory recommendations to be considered by the City's Planning Commission and City Council[2]. We presented progress to date, answered questions about process and findings, and led participatory engagement activities to gather input from the CRAB about community assets and observed impacts of climate change[3]. At the conclusion of the project, we presented a summary of the work as well as policy recommendations to the City Council for future consideration.

[1] In attendance: Brady Begin, Brooke Eidem, Nova Heaton, Duane Leach, Yoshihiro Monzaki, Cody Morton, Andrew Sics, and Heather Thomas

[2] In attendance: Brady Begin, Brooke Eidem, Alaksandar Babic, Marie Blakey, Elle Holtz, Leslie Indresand, and Michelle Madejski

[3] See Appendix G for details.

Greenhouse Gas (GHG) Assessment

In alignment with climate planning best practices, our team conducted a greenhouse gas (GHG) emissions inventory. To begin the process, we researched GHG inventory methods and tools. We chose to use the International Council for Local Environmental Initiatives (ICLEI)[4] ClearPath software after comparing many options to conduct a community-scale Scope 2 inventory. This means that we calculated the emissions generated within the City as well as emissions from natural gas and electricity used by Snohomish residents.

We sent out data collection requests to utility providers for the City. This data was collected, cleaned, and input into the ClearPath software. For emissions sources not from a particular utility (refrigerants and transportation), we researched methods for calculating estimates. Another key input was factor sets. These are sets of information related to emissions such as the composition of landfill waste and population growth projections.

We then analyzed the data. From these results, we generated a 2022 GHG emissions inventory and an emissions forecast from 2022-2050. The inventory shows that residential natural gas use contributes about half of the City's GHG emissions, and the second largest source of emissions is personal vehicles.

Based on the combination of the inventory and the forecast, we generated science-based emissions reductions for the City. We propose a 35% reduction in GHG emissions by 2030, 75% by 2040, and 95%, or net-zero, by 2050. From our analysis, we can see that the 2030 goal could be easily achieved solely through reducing residential natural gas use. To accomplish this goal, our team explored many policy and strategy options and included a preliminary inventory and estimated storage of the City's carbon sinks[5].

Existing Impacts

We analyzed the baseline climatic conditions and trends within the City of Snohomish, which served as the foundation for subsequent analyses.[6] Our analysis included understanding current trends in precipitation; snowpack; flooding; temperature; urban heat; and wildfire and smoke, as we determined these to be the most relevant climate change indicators for Snohomish. Importantly, we then evaluated how these climate change impacts affect the City's vulnerable populations. As vulnerable populations may be most impacted by urban heat, our analysis also includes an Urban Heat Island Analysis, including several maps.

Our analysis relied on the University of Washington's Climate Impact Group's written reports and *Tableau Northwest Climate Trends Tool*, historic river flow data, satellite data, as well as consultation with City staff and climate change experts. We learned that increasing temperatures and changes in precipitation drive the most important climate change impacts to the City. These impacts include increased urban heat, summer drought, more wildfire smoke, and more intense rain events and reduced snowpack that lead to increased winter flooding. These impacts lead to worsened health outcomes, degradation of

[4] Now known as "Local Governments for Sustainability"

[5] See Section 8: Carbon Sinks identification & Storage

[6] See Section 3: Climate Projections for the City of Snohomish and Section 4: SWOT Analysis of Climate Change Driven Risks to Assets

habitats (e.g. loss of wetlands and trees) and increased pressure on important species (e.g., salmon, birds, other wildlife), as well as economic impacts (e.g., loss of tourism, damages to businesses, homes, and infrastructure). These impacts disproportionately affect Snohomish's vulnerable populations (e.g., the elderly, low-income, children, those with disabilities or medical conditions).

Future Projections

After analyzing the existing impacts, we investigated different scenarios for how the City may be impacted by climate change in the future. Using projections from the University of Washington Climate Impacts Group's *Climate Mapping for a Resilient Washington* webtool, we analyzed the key climate hazards of extreme heat, extreme precipitation, flooding, and drought for Snohomish County and the Snohomish and Pilchuck Rivers. The projections are based on historical data from 1980-2009 and model different possibilities for future conditions for different timeframes and relative concentrations of greenhouse gas emissions. While we considered how the results will impact the City of Snohomish, please note that the climate projections should not be scaled down to a city-scale. The most downscaled data was from looking into the streamflow and river conditions of the portions of the Snohomish and Pilchuck Rivers within the City boundaries.

We chose to analyze two different emissions models and time horizons to assess future climate impacts. Using a high emissions scenario and a low emissions scenario across the near term (2049) and long term (2079) we were able to give the City a range of future possibilities. After examining the different projections, we studied how the climate hazards may impact the City's key sectors and assets. This analysis revealed the overlapping effects extreme heat, extreme precipitation, flooding, and drought have on key sectors in the City and region. A significant takeaway from analyzing the future projections is the possibility for more severe extreme heat, extreme precipitation, flooding, and drought events under a higher emissions scenario. Comparing the outcomes between projections for different hazards and their climate indicators reflects the importance of mitigating emissions to decrease the likelihood of more severe impacts to the City's residents and assets. However, impacts will also occur under low emissions scenarios, emphasizing the need for both adaptation (preparing for climate change impacts) and mitigation (reducing greenhouse gas emissions) strategies.

Risk Assessment

We began by outlining a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis geared towards risk assessment in a city, rather than the sustainability of a single business. In this format, Strengths were assets, Weaknesses were the vulnerabilities of the assets, Opportunities were the policies and interventions to be identified, and Threats were the specific hazards. We developed a list of assets of the city, and a list of hazards that the city was likely to experience. The assets included buildings, bridges, homes, community spaces, wetlands, rivers, and pieces of infrastructure such as the wastewater treatment plant. The hazards were river flooding, wildfire smoke, and extreme heat effects. We created a "Risk Matrix" with two axes; one for the severity of the impact and one for the likelihood of its occurrence. The final spot each asset occupied on the grid spoke to both its importance and to its vulnerability. We delivered a SWOT Analysis memo and a finalized risk matrix based on a four-category individual risk rating and a three-category cumulative risk rating.

Gap Analysis

We conducted a Gap Analysis of the City's Comprehensive Plan using criteria from the Washington State Department of Commerce Model Climate Elements guidance. We searched for gaps primarily within the Environmental Protection element but also analyzed other sections from an environmental protection and climate impact perspective. We generalized the identified gaps into three broad categories as follows: policies or goals that directly conflict with mitigation planning; policies or goals that do not consider climate adaptation/changing risks; and policies or goals that would benefit from more precise or stronger language. All nine elements of the Plan contained at least one example of one or more of the three categories of criteria. The most significant takeaway was not so many instances of omission or direct conflict, but of instances of the lack of more precise or stronger, action-oriented language.

The Final Compiled Report contains our recommendations for the areas in each element that could benefit from a more thorough integration of climate mitigation and adaptation across each element, a focus more on mitigation than adaptation, and stronger, more-action-oriented language[7].

Review of Climate Goals and Regulatory Framework

We reviewed 11 climate change policies, plans, and regulations: five bills and acts from Washington State, two plans and relevant documents from the Puget Sound region, and four plans from Snohomish County. The purpose of this review was to understand climate adaptation and mitigation regulations, bills, plans, and relevant documents at the state, regional, and county levels. We identified the following sectors to be the most relevant for the City of Snohomish: Emergency Management, Greenhouse Gas (GHG) Emissions Reductions, Buildings & Energy, Ecosystems, Health & Wellbeing, Transportation, Water Resources, Cultural Resources & Practices, and Economic Development.

Common themes across the reviewed policies, plans, and regulations include supporting vulnerable communities, protecting and enhancing ecosystems, transitioning to a clean energy economy, and building resilience across infrastructure. The regulatory framework reveals how the state, regional, and county goals support the City's role in climate action. The City should look to higher levels of government for technical and financial support and cross-jurisdictional collaboration. Cross Jurisdictional / Regional Collaborations goals include improving regional collaboration across jurisdictions, including with Tribal Nations, agencies, and non-governmental organizations, to advance resilience, adaptation, and mitigation actions (Puget Sound Regional Council, the Snohomish County Hazard Mitigation Plan, and the County Comprehensive Plan). Identifying synergies, utilizing regional resources, and accessing financial and technical support will maximize the City's effectiveness and reduce its costs in building climate resilience across all sectors.

Policies, Goals, Strategies, and Plans

The goals and policies included in the Department of Commerce's Climate Measures document are a synthesis of policy recommendations from a wide range of state and federal agencies as well as the University of Washington Climate Impacts Group and the C40 Cities Climate Leadership Group.

[7] See Section 6: Environmental Protection Element Gap Analysis for further details.

Based on the Department of Commerce Climate Measures, we compiled a comprehensive menu of policies most applicable to the City of Snohomish. We then compared the policy language to the state and county-level regulations and policies, revised them to eliminate redundancies, and improved the relevance to projected climate hazards most important to the City of Snohomish. The results of the gap analysis were also reviewed to determine if the provided policies meet an identified gap in the City's Comprehensive Plan or are consistent with an existing policy. The resulting Tailored Policy Menu, *Appendix G*, outlines 31 goals with 139 supporting policies across 10 Climate Nexus Sectors. This Tailored Policy Menu includes estimates of the expected impact of each goal/policy, meaning the extent to which implementation of the goal or policy will mitigate greenhouse gas emissions or build resilience to a specific climate hazard. The Menu also includes the estimated cost of implementing each goal/policy, the anticipated timeline for implementation, and considerations regarding the feasibility of implementing the goal/policy within Snohomish. These descriptors are intended to assist City staff and other stakeholders in deciding which policies to include in the 2024 Comprehensive Plan Update.

Key Takeaways & Next Steps

A significant portion of identified policies that will help the City of Snohomish achieve its climate goals are related to the 'Transportation' and 'Zoning & Development' Climate Nexus Sectors. Land use decisions coupled with an increase in multimodal transportation options within the City will be critical in creating a path towards meeting the City's overarching emissions reduction targets and building a more resilient Snohomish. Many of the policies identified are also directly related to ecosystems and water resources and will help strengthen the existing Environmental Protection element. These policies highlight the importance of protecting and enhancing the natural environment in and around Snohomish for current and future generations. Snohomish faces significant climate change impacts that pose a particular threat to its ecosystems. Preserving the long-term functionality of these ecosystems is crucial for ensuring overall resilience to climate change.

Many policy recommendations have the potential to impact the well-being of the people that call Snohomish home. Due to this, 'promoting equity and justice' is frequently listed as a potential co-benefit of recommended policies, as it is essential for the City to plan for and uplift the most vulnerable members of the community. As of this report, the Washington State Department of Commerce is still developing the "Climate Equity and Uplift Community Leaders" section of the Climate Element Planning Guidance. This prevented us from using this resource in our analysis and recommendations; however, we urge the City to refer to this resource when it becomes available.

The preceding sections discuss the results of our quarters-long research and the resultant recommendations. For a more complete and in-depth look at processes and methods, as well as further information, graphics, data tables and maps, please refer to our final report titled *Planning for Climate Change: Integrating Climate Mitigation & Adaptation into the Comprehensive Plan for the City of Snohomish*.

.

Section 1: Greenhouse Gas Emissions Analysis for the City of Snohomish

Glossary of Terms for Section 1

The following terms and abbreviations are commonly used in climate science and planning:

Adaptation - Changes to policy or behavior to reduce harm from climate impacts.

Business-as-Usual - The planning scenario in which no efforts are implemented to reduce greenhouse gas emissions from 2022 levels.

Carbon intensity - A measure of how clean a source of energy is, referring to the amount of carbon dioxide equivalent (CO2e) emitted to the atmosphere per unit (kilowatt hour) of electricity produced.

Clean energy - Electricity or heat produced without fossil fuels. Generates little to no GHG emissions.

Climate change - The altering of natural weather patterns, including average and extreme temperature, precipitation, sea level, and others. Human-caused climate change is due to global warming from greenhouse gas emissions.

CO_2 - Carbon dioxide. The primary greenhouse gas emitted by human activities.

CO2e - Carbon dioxide equivalent. This is the standard measure all GHG emissions are converted into to allow for comparison.

Co-benefit - A strategy that achieves multiple goals simultaneously. Often used when talking about adaptation and mitigation strategies that serve to both reduce greenhouse gas emissions and harm from climate impacts.

Community-level inventory - A type of GHG emissions inventory that includes emissions generated by activities of residents in a jurisdiction within the boundaries of the jurisdiction.

Greenhouse Gas (GHG) - Often talked about in terms of emissions caused by human behaviors. These include carbon dioxide, methane, nitrous oxide, and others and are the gasses in the atmosphere causing climate change.

Global warming - Increases in the global average air temperature due to greenhouse gas emissions. Often measured annually.

Global Warming Potential (GWP) - The amount of warming caused by one unit of a given GHG. They can vary greatly between different types of GHGs.

ICLEI - ICLEI Local Governments for Sustainability (formerly known as International Council for Local Environmental Initiatives) is a non-governmental organization that promotes sustainable urban development in local governments around the world.

ICLEI ClearPath - Software developed by ICLEI to conduct GHG emission inventories, forecasts, and planning scenarios. This is the software that was used to conduct Snohomish's inventory and forecasts.

Mitigation - Reduction of greenhouse gas emissions to slow climate change and global warming.

Metric Tons (MT) - Used to measure CO2e. One MT is equal to 0.000001 MMT.

Million Metric Tons (MMT) - Used to measure CO2e. One MMT is equal to 1,000,000 MT.

Net-zero - The condition under which any GHGs emitted to the atmosphere are balanced with GHGs removed from the atmosphere, which is achieved by carbon sequestration in natural systems like wetlands and forests.

Process and fugitive emissions - The unintentional emissions of greenhouse gasses from leaks or inefficiencies in pressurized equipment such as valves, flanges, pumps, tanks, compressors, etc.

Science-Based Target - A greenhouse gas emissions reduction goal based on an understanding of how many greenhouse gasses the atmosphere can physically absorb before negative impacts are observed.

Scope 2 - A type of GHG emissions inventory that includes GHG emissions generated by activity within the boundaries of a jurisdiction as well as emissions from generation of energy used in the jurisdiction.

United States Community Protocol (USCP) - Methodologies and best practices for conducting community-level GHG inventories developed by ICLEI.

2022 GHG Emissions Inventory

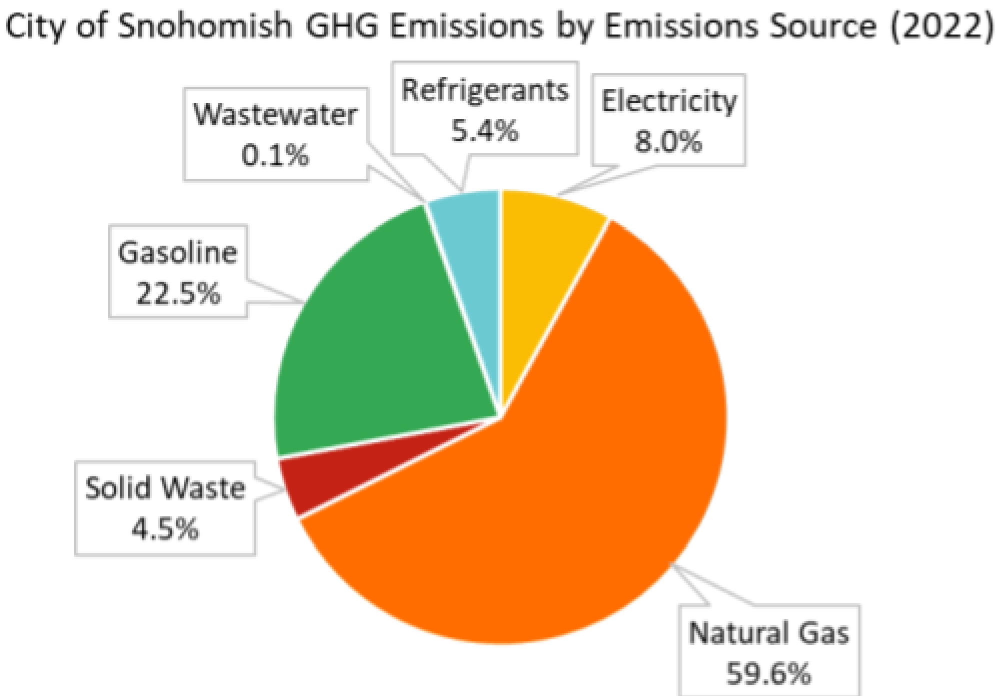


Figure 1.1: 2022 City of Snohomish GHG Emissions by Source

GHG emissions inventories are an important step in climate action planning. They allow jurisdictions to understand how they are contributing to climate change and where to make the most impactful interventions. There are many different types, scopes, protocols, and methods for conducting GHG inventories. We conducted research on these differences in the Winter Quarter, and more information can be found in the previous Initial Conditions Report.

For the City of Snohomish, our team chose to conduct a Scope 2, community-level inventory following the United States Community Protocol. The process of conducting the inventory involved sending data requests to utility companies, research on carbon intensity of activities, and developing estimates for refrigerant and transportation emissions. All of these process documents and raw data points are included in a compiled folder the City can use to generate future inventories or conduct further study using our 2022 calculations.

The results of this inventory are illustrated in Figure 1.1 - this chart is broken down by emissions source, by far the largest of which is the burning of natural gas for heat, cooking, and energy. A detailed breakdown of emissions by source can be found in Table 1.1. This type of breakdown by emissions source can be useful to identify the types of fuel that could be swapped for a clean energy source. All tables and figures in this section are based off of our team's work unless otherwise noted.

Another way to break down emissions is by sector. Figure 1.2 and Table 1.2 provide a detailed breakdown of emissions by sector. Here we can see that it isn't just natural gas that contributes the most emissions, but specifically natural gas used in residential homes. *Appendix A: 2022 City of Snohomish GHG Inventory Data* outlines how utility categories are classified, but generally 'residential' in this inventory refers to single-family dwellings.

When looking at broad categories such as source or sectors, it is important to look at more detailed breakdowns as well. Figures 1.2-1.4 illustrate the sub-categories within Residential Energy, Commercial Energy, Solid Waste, and Process & Fugitive emissions. From Figures 1.2 and 1.3, we can see that natural gas is by far the strongest energy emitter across sectors. Figure 1.4 illustrates the breakdown of emissions from solid waste into parts of the landfill process. Here we can see that landfill waste itself is the largest emissions source by far in the waste disposal process. This indicates that there could be many reductions made by encouraging recycling and composting in the City.

However, this inventory will likely be most useful as a baseline. As the first GHG emissions inventory ever conducted for the City, it will be the measuring stick for all future emissions reductions measures. It can serve as a powerful tool to illustrate the impact and importance of mitigation measures, as well as a quantitative data point to apply for project funding and gain public buy-in. This inventory also allowed our team, and eventually the City itself, to create emissions reductions goals and policies that are feasible, impactful, and actionable.

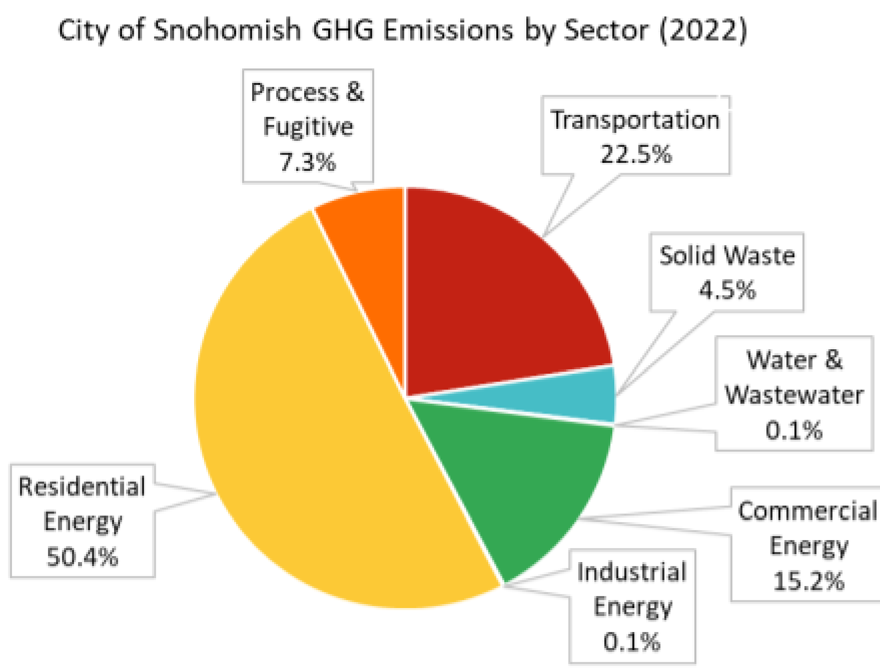


Figure 1.2: City of Snohomish GHG Emissions by Sector

Table 1.1: 2022 City of Snohomish GHG Emissions by Emissions Source

Emissions Source	CO2e (MT)	Sub-Category	CO2e (MT)
Electricity	8,180.21	Residential	6,401.80
		Commercial	1,707.50
		Street Lights	41.86
		Wastewater treatment	29.04
Natural Gas	60,793.07	Residential	44,993.00
		Commercial	13,776.00
		Industrial	103.67
		Natural gas loss	1,920.00
Solid Waste	4,557.94	Compost	224.82
		Landfill waste	3,798.30
		Landfill gas flaring	101.51
		Landfill gas combustion	433.31
Gasoline & Diesel	22,927.57	City fleet gasoline	90.45
		City fleet diesel	33.12
		Personal VMT estimate	22,800.00
Wastewater	63.06	N2O use	0.00
		Effluent discharge	63.06
Refrigerants	5,482.00	Refrigerants	5,480.00
		TOTAL:	101,997.45

Table 1.2: 2022 City of Snohomish GHG Emissions by Sector

Sector	CO2e (MT)	Sub-Category	CO2e (MT)
Transportation	22,969.44	City fleet gasoline	90.45
		City fleet diesel	33.12
		Personal VMT estimate	22,800.00
		Street Lights	41.86
Solid Waste	4,557.94	Compost	224.82
		Landfill waste	3,798.30
		Landfill gas flaring	101.51
		Landfill gas combustion	433.31
Water & Wastewater	92.11	Electricity use	29.04
		N2O use	0.00
		Effluent discharge	63.06
Commercial Energy	15,483.50	Electricity	1,707.50
		Natural gas	13,776
Industrial Energy	104.00	Natural gas	103.67
Residential Energy	51,394.80	Electricity	6,401.80
		Natural gas	44,993.00
Process & Fugitive	7,402.40	Natural gas losses	1,920.00
		Refrigerants	5,480.00
		TOTAL:	101,997.45

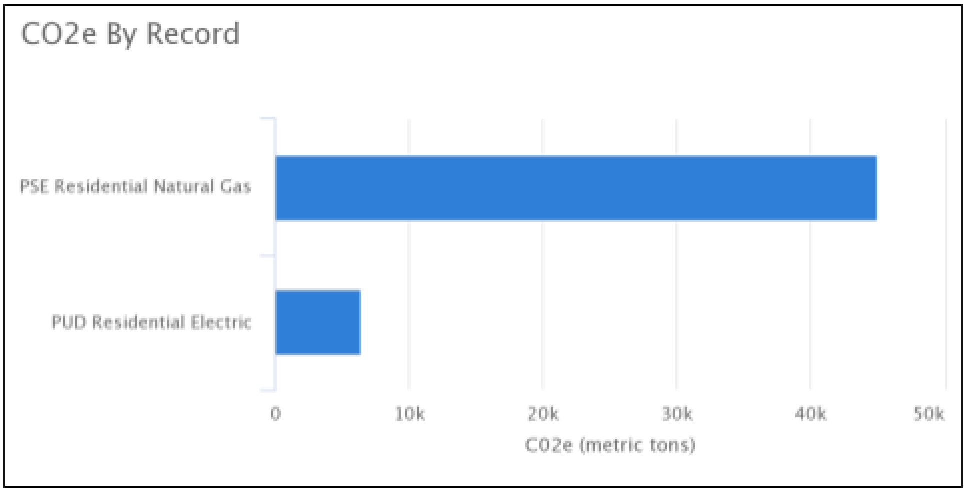


Figure 1.3: Emissions of residential energy use

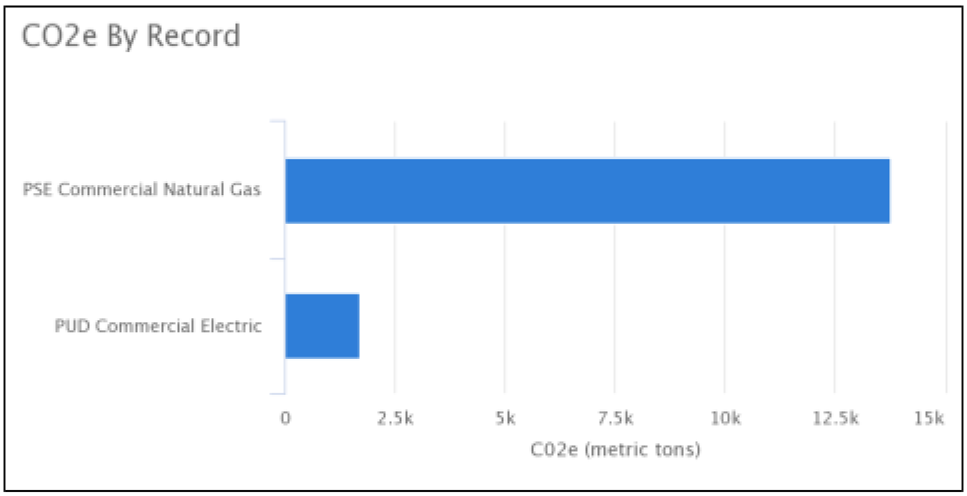


Figure 1.4: Emissions of commercial energy use

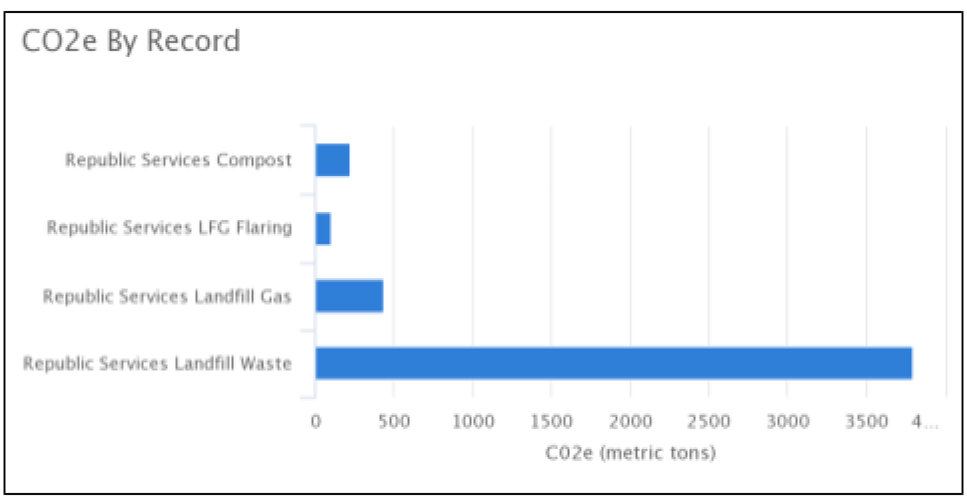


Figure 1.5: Emissions of solid waste

2022-2044 GHG Emissions Forecast

GHG emissions forecasts are generated to understand how business-as-usual (BAU) activity will affect future emissions. This is important to identify where the most impactful interventions can be made, and to generate planning scenarios to reach reduction goals. Figure 1.5 illustrates our forecast for the City of Snohomish. The vertical axis represents the amount of emissions in MT CO2e, and the horizontal axis represents time. Each tick mark represents one year, and this forecast extends to 2044, aligning with the

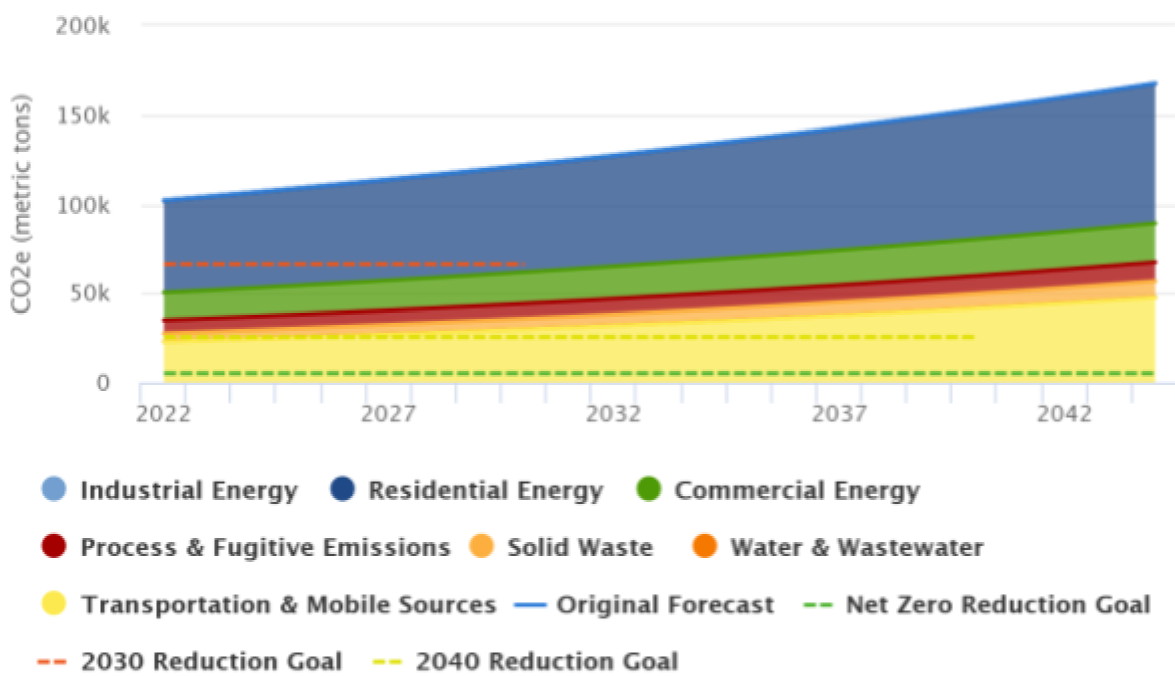


Figure 1.6: 2022-2044 GHG Emissions Forecast for the City of Snohomish

comprehensive planning horizon. This graph is not cumulative – the CO2e value shown at each year is the amount of emissions *from that year*. The amount of emissions *per year* will be increasing, which will in turn increase the City's cumulative GHG emissions. As CO_2 constitutes the majority of emissions and remains in the atmosphere for 300 to 1,000 years, it is critical to understand the cumulative nature of GHG emissions (Buis 2019).

Our BAU forecast for 2022-2044 is based on the 2022 GHG Emissions Inventory and official Office of Financial Management (OFM) population and employment growth projections for the City. This forecast does not include the impacts of recent state policies or regulations to reduce GHG emissions, technological advancements, or behavior changes in response to climate impacts.

However, the forecast illuminates some critical points for the City. The most important is simply the fact that without action, the City's contribution to state and county emissions will continue to grow. While Snohomish's emissions seem inconsequential compared to these larger totals, without action the portion of these emissions attributable to the City will increase as state and other local governments decarbonize. The forecast also illustrates the importance of early interventions. For example, by switching away from natural gas energy in single-family homes by 2040, the City can prevent 50,000 MT of CO2e from entering the atmosphere for *every following year.*

The dashed lines on Figure 1.5 represent the science-based targets we have generated for the City. These will be discussed in more detail in the next section, but the forecast shows how much easier the targets are to reach through early action. Meeting the 2050 95% reduction goal in 2025 would require eliminating 103,497 MT of CO2e, whereas if no action is taken on reductions until 2044, 155,596 MT of CO2e would need to be eliminated in just six years. Actions need to be taken now to feasibly reach the targets of Washington State policy and the Paris Agreement.

GHG Emissions Reduction Science-Based Targets

A science-based target (SBT) is a GHG emissions reduction goal in line with climate science and often consistent with the goals of the Paris Agreement. SBTs are established to limit global warming to 1.5 degrees Celsius (2.7 degrees Fahrenheit), but no more than 2.0 degrees (3.6 degrees Fahrenheit) above pre-industrial temperatures. 1.5 degrees of warming is considered by climate scientists around the world as a critical ecological tipping point for human and ecosystem survival. To achieve this goal, the globe must have net-zero carbon emissions by 2050.

Washington State is committed to reaching net-zero by 2050. State policy outlines reduction goals of 45% by 2030, 70% by 2040, and 95% by 2050. Table 1.3 further details reduction goals and emissions totals that are relevant to and include Snohomish. While the City's emissions are only a fraction of county, regional, or state totals, every MT of carbon in the atmosphere counts when considering the urgency of reaching net-zero.

Table 1.3: Relevant GHG Reduction Goals and Emissions Totals

Agency	Base Year	Base Year Total	Most Recent Total	2030	2040	2050
The United Nations - Paris Agreement	1990	22.4 GtCO2e	36.8 GtCO2e	-45%	N/A	-100%
Washington State	1990	93.5 MMT CO2e	102.1 MMT CO2e	-45%	-70%	-95%
Puget Sound Regional Council	1990	unknown	36.634 MMT CO2e	-50%	N/A	-80%
Snohomish County	2015	5.187 MMT CO2e	6.8 MMT CO2e	N/A	N/A	N/A
City of Snohomish*	2022	.1 MMT CO2e	.1 MMT CO2e	-35%	-75%	-95%
*Goals are proposed. Sources: Puget Sound Clean Air Agency 2017, Snohomish County 2022, United Nations 2015, and Washington State Legislature 2020						

We recommend SBTs for Snohomish based on these broader emissions reduction goals and our forecast. Knowing that SBTs require a net-zero emissions goal by 2050, we chose to align Snohomish's reduction goal with the State's net-zero definition of a 95% reduction. From there, we worked both backwards from 95% and forwards from the 2022 inventory to develop feasible mid-point reduction goals. Table 1.4 outlines the recommended SBTs we have generated and what they equate to.

Table 1.4: Science Based Targets (SBTs) for GHG Emissions Reductions in the City of Snohomish

Year	Percent Reduction from 2022 Baseline	Maximum Annual CO2e Emissions to Meet Goal
2030	35%	66,300 MT
2040	75%	25,500 MT
2050	95%	5,100 MT

For 2030, we chose a goal that could be achieved through a single set of reduction strategies. Residential natural gas use contributed 44,993 MT of CO2e to the City's 2022 emissions. The City can reach the 2030 35% reduction goal by minimizing its dependence on natural gas for residential energy. This could include switching homes to heat pumps (which also have the adaptation benefit of serving as air conditioners as well as heaters) and electric stoves[8].

To reach the 2040 reduction goal of 75%, the city will next need to address transportation. Gasoline consumption from personal vehicles is the second largest source of emissions for the City after natural gas; policies such as shifting to carbon-free transportation modes, like biking and walking, for intra-city trips and using electric vehicles for out-of-town trips will be key in achieving significant reduction. Though electric vehicles can still be perceived as an emerging option, there are many policy developments pushing the market to lower the price of electric vehicles and increase charging infrastructure[9]. Improvements to bicycle and pedestrian infrastructure within the City can also reduce the emissions from personal vehicle travel for short trips.

The final 20% reduction to reach net-zero in 2050 will likely be the most difficult to accomplish. Reaching this goal will require significant behavior change to reduce landfill waste, the third largest source of emissions. Waste education programs starting in the near future will likely be the most effective in reaching this goal.

GHG Emissions Discussion

There are key limitations to our GHG inventory. Transportation and refrigerant emissions calculations are estimates based on county-level data[10], meaning that larger municipalities such as Everett skew results.

[8] See Implementation Memo 7 for more detail on this strategy.
[9] See Section 5 and Implementation Memo 8 for more information.
[10] See Methods Section 1 for details.

We also did not include emissions from natural resource management practices, such as cutting down trees or tilling soil due to the limited data. It is also important to note that we conducted a Scope 2 inventory, only including activities within City boundaries plus utilities. In Snohomish, there is a large jobs-housing imbalance that leads to significant GHG emissions from commuting that are not captured in our inventory. To reach state and county emissions reductions goals, out-of-town vehicle trips will be an important area for further analysis.

There are key limitations to our emissions forecast as well. Based on the 2022 inventory, the transportation and refrigerant emissions projections are entirely reliant on estimates. The forecast also does not account for changes in carbon intensity, human behavior, federal or state policy, infrastructure, and many other potential drivers of emission change. We must also consider how adaptations to climate impacts will affect emissions. Hotter summers will increase air conditioner use, resulting in higher emissions from electricity and refrigerant usage. There may also be higher amounts of migration inland to temperate cities such as Snohomish as climate impacts become more severe, pushing the population growth rate and resulting emissions above forecasts.

There are many avenues for further exploration using the emissions forecast. Generating planning scenarios to illustrate the impact of various climate actions could be useful in prioritizing City strategies. A "wedge analysis", which would input the projected emissions reductions of state and federal policies and technological advances, would illustrate what emissions the City will still be responsible for eliminating through local policies. These analyses can be conducted using the ClearPath software with the 2022 inventory data, but may require the support of a climate professional to train City staff on the software's use.

These additional analyses would also be helpful in demonstrating the feasibility of Snohomish reaching its SBTs. To support this analysis, we have included outlines of several possible emissions reductions strategies in our Implementation Memos. These will be included in a supporting document to this report and will cover strategies for reducing emissions through heat pumps, electric vehicles, building codes, and distributed solar systems. Of course, these are only the tip of the iceberg when it comes to emissions reductions, but there are additional resources at the county, regional, and state level for the City to access.

Snohomish is well-situated to become a net-zero city by 2050. With 97% clean electricity, the City can confidently pursue electrification projects without worrying about non-renewable power sources. Current technologies exist to eliminate all of the City's natural gas, electricity, and transportation emissions. These technologies are becoming cheaper and more efficient as the markets for them increase. Washington State has strong climate legislation that is pushing utilities and other large emitters to reduce their emissions, as well as many incentive and funding programs to support climate mitigation projects[11]. The most impactful emissions reduction strategy, eliminating natural gas heating, is also a key adaptation strategy – the use of heat pumps and building envelope improvements provide present and future co benefits, simultaneously reducing emissions and providing relief from extreme heat events.

[11] See Section 5 for more detail.

Now is the time to begin the transition to a net-zero city. Snohomish has the potential to be a climate adaptation and mitigation leader, as the rest of this report will support. Strong community ties, respect for the natural environment, and the entrepreneurial spirit of the City contribute to this potential as much as the regulatory framework and clean electricity.

Section 2: Existing Climate Impacts for the City of Snohomish

This section evaluates the baseline conditions within the City of Snohomish, which will serve as the foundation for subsequent analyses (particularly, 'Climate Projections for the City of Snohomish' and 'SWOT Analysis of Climate Change Driven Risks to Assets'). We define the baseline conditions in the following sections below: Precipitation; Snowpack; Flooding; Temperature; Urban Heat Island Analysis; and Wildfire and Smoke. Additionally, we discuss the composition of the City of Snohomish and which populations may be more susceptible to the harms climate change causes.

2.1: Existing Climate Change Impacts & Historical Trends

Increasing temperatures and changes in precipitation drive the most important climate change impacts to the City. These impacts include increased urban heat, summer drought, more wildfire smoke, and more intense rain events and reduced snowpack that lead to increased flooding. While it is difficult to attribute any one extreme event to climate change, we can identify significant trends in climate change indicators, including temperature, precipitation, snowpack, and flooding patterns.

We used the University of Washington's Climate Impact Group's *Tableau Northwest Climate Trends Tool* to understand local trends in temperature, precipitation, and snowpack. The tool shows long-term trends in climate change indicators. We only included statistically significant trends (labeled "S") in our analysis.

Precipitation

Overall, total annual precipitation has been increasing in the region for more than a century. Observations near the City of Everett, which is the closest dataset location to the City of Snohomish, show an increasing trend in both the annual precipitation (Figure 2.3) and the March-April-May springtime precipitation (Figure 2.4) over the past 120+ years. The annual precipitation trendline in Figure 1 shows a 1% increase in annual precipitation per decade from 1894 to 2020. The spring (March-April-May) trendline in Figure 2.4 shows a 0.2% increase in Spring (March-April-May) precipitation per *year* from 1892 to 2021 (Office of the Washington State Climatologist 2023).

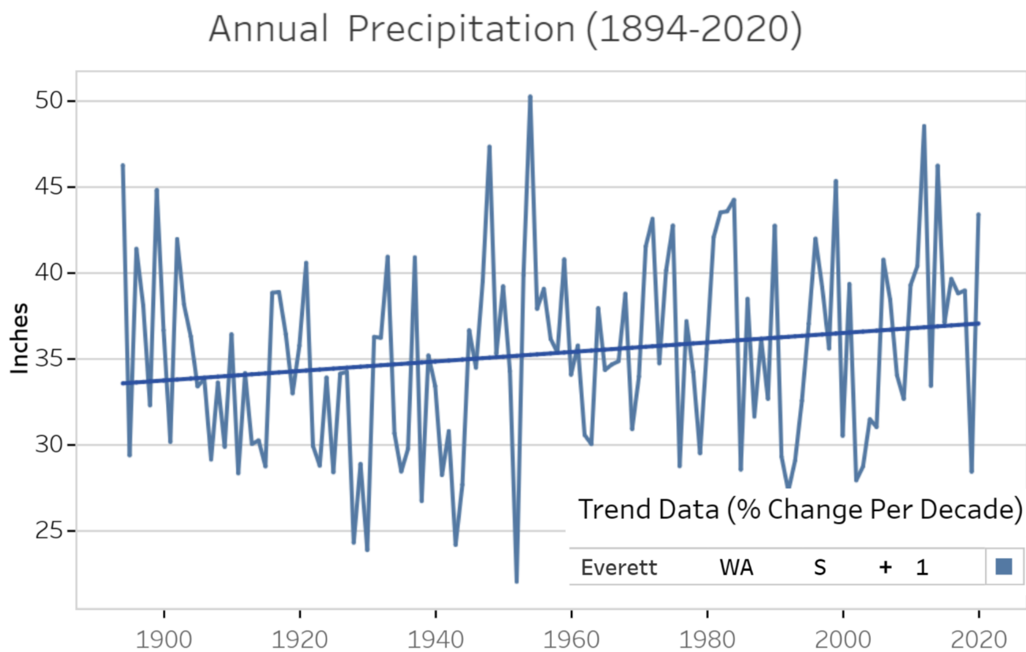


Figure 2.1: Annual Precipitation trend from 1894 to 2020 at Everett, WA. (Washington State Climatologist 2023)

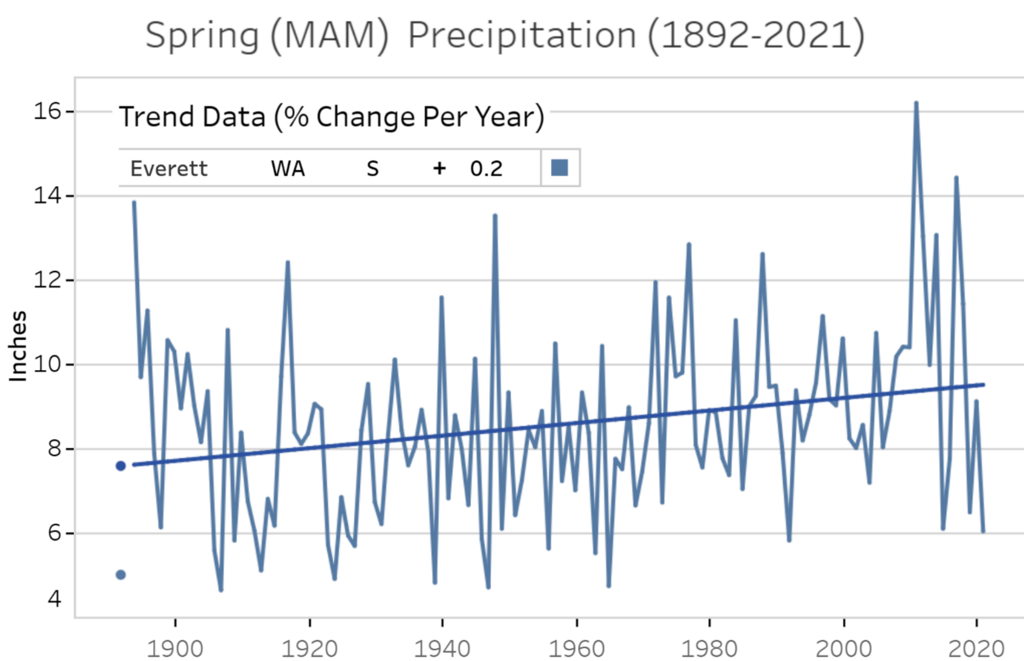


Figure 2.2: Springtime, or March-April-May (MAM), Precipitation trend from 1892 to 2021 at Everett, WA. (Washington State Climatologist 2023)

Snowpack

Snowpack is typically measured and converted to snow water equivalent (SWE), which is the amount of water that would be obtained from melting the snowpack based on its depth and density. Snowpack is typically measured at its peak in April. SWE relates to water storage potential in the upper portions of the watershed.

The Snohomish Basin is a mixed-rain-and-snow basin, which means snowmelt from the mountains and rain contribute to spring runoff and summer snowmelt feeds river flows that are important to fish. Warmer temperatures will cause more precipitation to occur as rain rather than snow in the mountains, and snowpack levels will decrease (Mauger et al. 2021). Less snowpack in the winter means less overall annual water storage leading to increased winter flooding, and lower summer stream and river flows.

Figure 2.5 shows a graph of the April SWE at the Tunnel Avenue station near Snoqualmie Pass from 1941 to 2021 (the year 2020 is missing). The snowmelt from the area flows into the Snoqualmie River, which is a major tributary to the Snohomish River. The trendline shows a 5.6% decrease in SWE per decade over about the past 80 years. Other Snoqualmie Pass area stations, listed in Table 2.1 below, show similar significant decreasing trends ranging from -3.4 to -11.7% decrease per decade in April SWE.

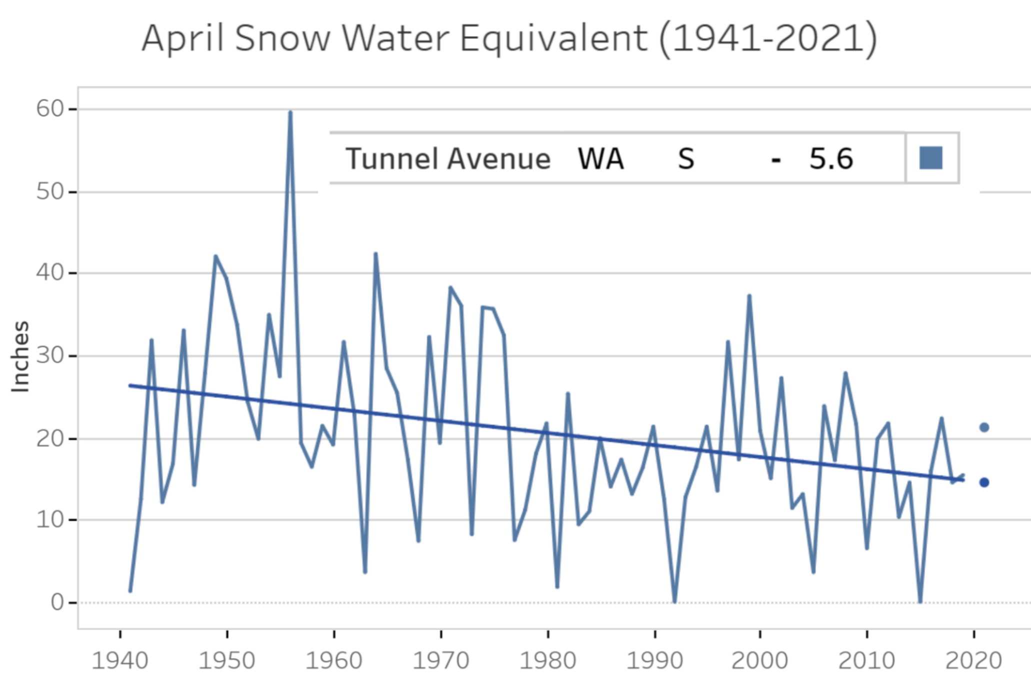


Figure 2.3: April SWE trend from 1941 to 2021 at Tunnel Avenue near Snoqualmie Pass. (Washington State Climatologist 2023)

Table 2.1. Significant historical SWE trends in Snoqualmie Pass area stations, where the "S" denotes statistical significance. (Washington State Climatologist 2023)

Historical SWE Trends - Snoqualmie Pass Area Stations		
Significant (S) Trend Data (% change per decade)		
City Cabin WA	1948 - 2021	-11.7
Fish Lake WA	1943 - 2021	-3.4
Mt. Gardner WA	1959 - 2021	-3.7
Olallie Meadow WA	1945 - 2007	-9.3
Tunnel Avenue WA	1941 - 2021	-5.6

Flooding

Increasing precipitation, more intense rain events, and reduced snowpack can lead to increased winter flooding, especially in mixed-rain-snow basins like the Snohomish (Mauger et al. 2021). To understand the flooding history of both the Snohomish and Pilchuck Rivers, we analyzed past flood records to identify patterns or trends. Historical flood data was obtained from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service (NWS) website. The Snohomish River (SNAW1) gauge located at the City of Snohomish & the Pilchuck River (PILW1) gauge located near the City provided data for the flood records (NOAA 2020).

Figure 2.4 (below) shows a graph of the recorded flood events from 1942 to 2022 on the Snohomish River. NWS, an agency of NOAA, defines the flood categories on the river as: *Flood Stage* at 25 feet; *Moderate Flood Stage* at 27 feet; and *Major Flood Stage* at 29 feet or more. It is important to note, however, that the names of the flood stages can be misleading. When the river reaches the Major Flood Stage, it does not mean that the area experiences major, disruptive flooding (resulting in road closures, for example).

The Major Flood Stage category has a return period of approximately three years, while flood levels that cause more disruptive flooding events have a return period of about five years where the river level reaches 30 feet or higher. For reference, the November 2015 storm event that caused disruptive flooding reached a flood stage of 30.9 feet. The river's highest ever recorded flood stage was 33.5 feet in late November of 1990.

Figure 2.4 shows that reaching a flood stage of 30 feet or more did not happen before 1951. The graph shows a group of extraordinary flood events (above 32 feet) that did not occur until after 1975 and now have an average return rate of about seven years, the last of which occurred in 2009. This increase in magnitude of flood events could be attributable to increased development in the watershed, including river channelization, increased impervious surfaces and conversion of forestland to agriculture

(Snohomish County Public Works 2010) and could also be exacerbated by changes in precipitation patterns resulting from climate change (Mauger et al. 2021).

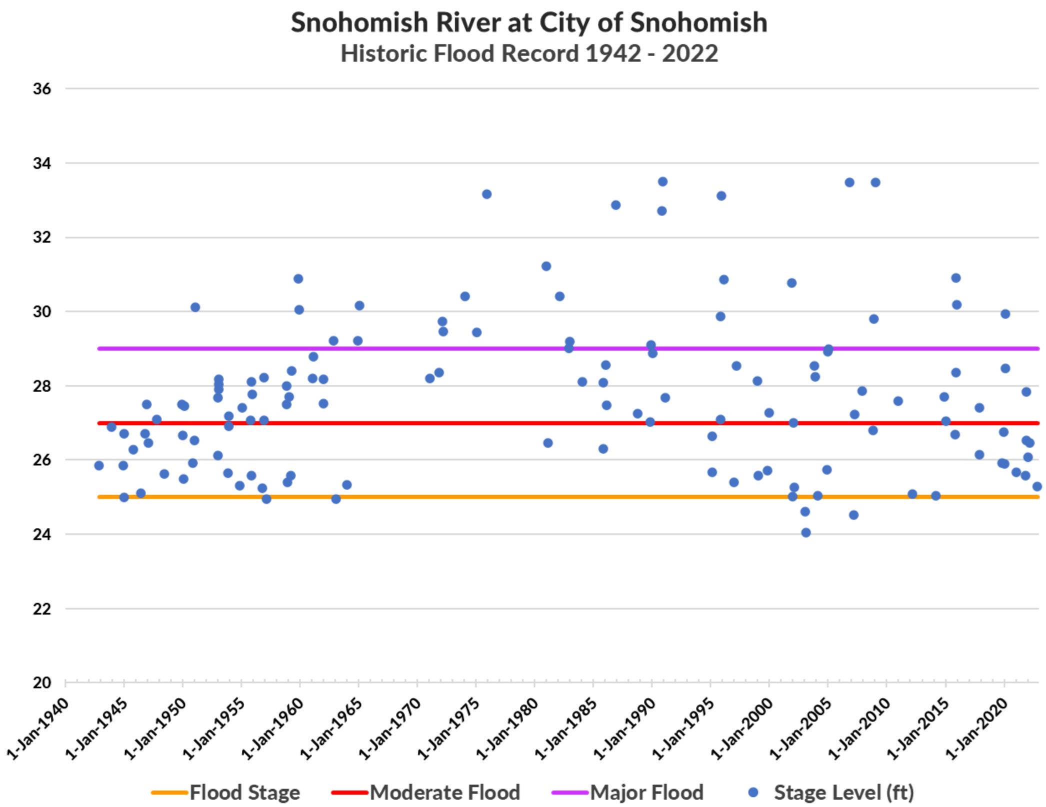


Figure 2.4: Snohomish River Historical Flood Record from 1942 to 2022. (NOAA 2020)

Table 2.2 (below) shows trends across flood stage categories reached each decade. In the 1940s there were many smaller flood events (with river water levels of 25 feet or more) but few moderate events and no major flood events. The 1950s saw a large increase in moderate flood events and the first few major events. This increase corresponds to major increases in development of the watershed. Major flood events became more common from the 1970s through 1990s and have decreased some over the last 10-15 years, with the last flood over 30 ft. in 2015 and over 32 ft. in 2009. This decrease could be the result of improved watershed management, more effective flood control projects, or natural variability in the historical record. An exploration of the cause of the decrease was out of the scope of our analysis and therefore it is unclear whether the trend will persist.

Table 2.2: Snohomish River at City of Snohomish Historical Decadal Trends. (NOAA 2020)

Snohomish River at City of Snohomish Historical Decadal Trends											
1942 -2022 (80 year record)		1940s	1950s	1960s	1970s	1980s	1990s	2000s	2010s	2020-2022	
Flood Categories (ft)		# of times reached flood categories during decade									Total
Major Flood Stage	29+	0	3	3	5	6	5	4	2	1	**29**
Moderate Flood Stage	27+	3	16	4	0	6	6	7	6	2	**51**
Flood Stage	25+	11	12	2	2	2	5	5	5	7	**48**
Total		**14**	**31**	**9**	**7**	**12**	**16**	**16**	**13**	**10**	**128**

Several City staff members asked our team if recent restoration efforts to restore the floodplain downstream of the City have decreased the potential for flooding within the City. To answer this question, we referred to a report on the flooding dynamics of the Snohomish River (Mauger et al. 2021) as well as contacted Aaron Kopp, Water Resources Engineer for Snohomish County. According to Kopp, the recent restoration activities near Everett and Marysville do not affect the flood risk at the City. He also explained that although the Snohomish River is still tidally influenced as far upstream as the City of Snohomish, an extreme rain event combined with a king tide is possible but extremely rare. Therefore, sea-level rise has a negligible effect on the City's flood risk.

Identifying flooding trends on the Pilchuck River is difficult as the available historical flood record is much shorter, spanning from 1993 to 2019. However, a similar trend of an increase in moderate flood events is evident in the record (Figure 2.5). Additionally, City staff shared anecdotal evidence during our meeting on April 24, 2023, that in recent years there has been an increase in localized flooding along the Pilchuck River.

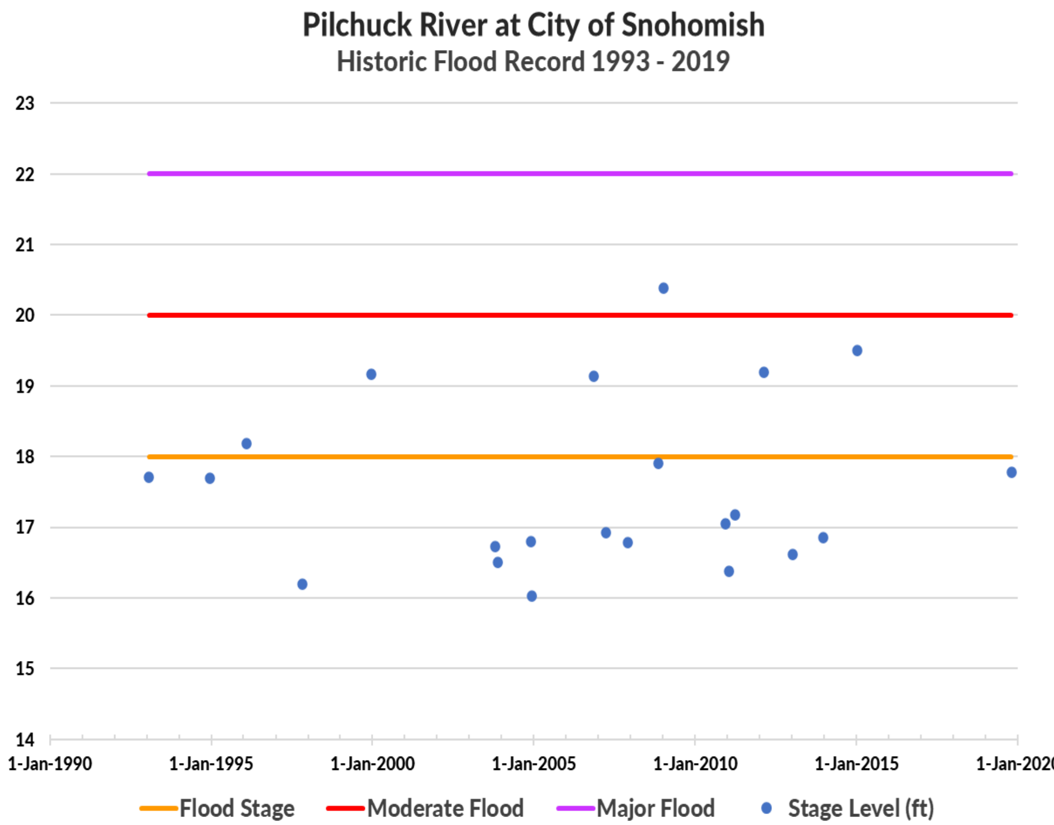


Figure 2.5: Pilchuck River Historical Flood Record from 1993 to 2019. (NOAA 2020)

Temperature

According to The Intergovernmental Panel on Climate Change (IPCC) recent report, temperatures are rising globally due to human induced climate change. The global surface temperature reached 1.1°C above 1850–1900 baseline temperatures between 2011 and 2020 (IPCC 2023). The following graphs show an increasing trend in the City of Everett's (the closest dataset location to the City of Snohomish) annual average temperature (Figure 2.6) and annual average maximum temperature over the past 120+ years (Figure 2.7). Figure 2.6 shows a statistically significant trendline of 0.18°F increase in annual average temperature per decade from 1896 to 2020. Figure 2.7 shows a statistically significant trendline of 0.13°F increase in annual average temperature per decade.

While these temperature increases may seem small, a slight increase can mean the difference between rain or snow in the mountains. When temperatures are above the critical threshold for snow, we see decreased snowpack, which is the natural water storage mechanism for the region. This will lead to increased flooding in the winter/spring, and more severe drought conditions in the summer and fall. Increased temperatures also exacerbate the urban heat island effect, where the combination of heat absorbing impervious surfaces and low tree cover in developed urban areas increase ambient temperatures in the City, discussed in detail in the next section.

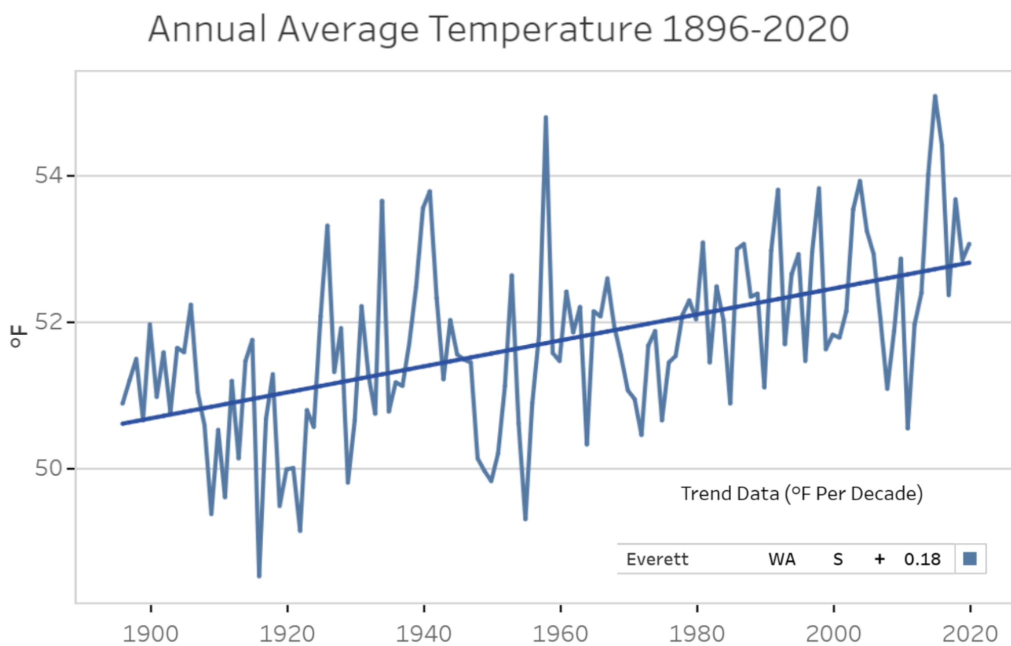


Figure 2.6: Annual Average Temperature trend from 1896 to 2020 in Everett, WA. (Office of the Washington State Climatologist 2023)

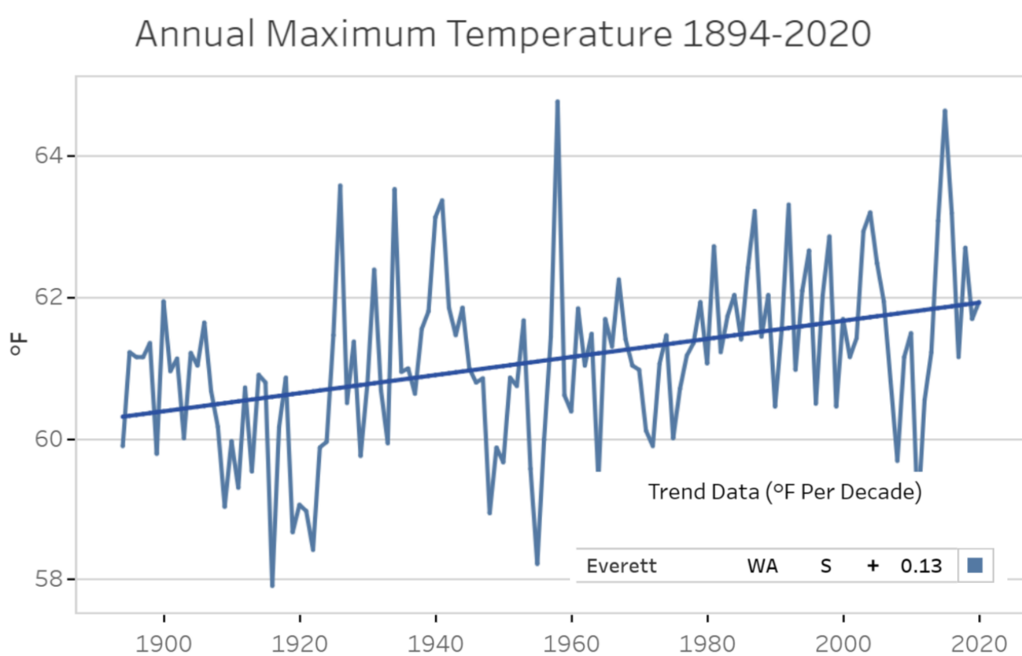


Figure 2.7: Annual Average Maximum Temperature trend from 1894 to 2020 in Everett, WA. (Office of the Washington State Climatologist 2023)

2.2: Urban Heat Island Analysis

As the City anticipates an increase in the number of days over 90°F, it is important to understand which areas of the City will feel the effects of extreme heat most acutely. Dark, heat-absorbing material and minimal tree canopy, make impervious areas feel hotter at the ground surface than vegetated areas with lots of tree canopy or reflective surfaces (Moore 2017 5). These hotter areas, called Urban Heat Islands (UHIs), absorb heat during hot days, emit heat overnight, and can average between 7°F and 27°F hotter than the measured ambient air temperature. The urban heat island effect is felt most acutely in the evening, when impervious surfaces have absorbed the heat of the day (Moore 5).

Land cover data and satellite imagery can approximate the extent of UHIs within a geographic area by comparing the land surface temperature to the measured ambient air temperature for the date, time, and location that the imagery was captured (Roy et al. 2021). We used satellite imagery to identify the UHIs within the City of Snohomish. Please find a more detailed description of our methodology in the Methods section.

Land surface temperature across the City of Snohomish was derived from imagery captured by Landsat 8. Landsat satellites capture images at 30-meter resolution across the electromagnetic spectrum, including infrared and near-infrared bands that can be converted to land surface temperature utilizing the method developed by Avdan and Jovanovska. ArcGIS Pro was used to determine the land surface temperature across the City of Snohomish using an image captured by Landsat 8 on July 28, 2022 at 6:55pm. We chose this because it was one of the few summertime images of the City that was captured during the evening and had low cloud or smoke cover that might interfere with image clarity. Once processed to land surface temperature, the ratio of surface temperature to ambient air temperature measured at the same date and time that the satellite image was captured was calculated at a 30-meter resolution across the city. This ratio was then multiplied by 90, 95, 100, and 105 to determine the variability of surface temperature in Snohomish for days where the ambient air temperature reaches 90°F, 95°F, 100°F, and 105°F. 90°F is considered the temperature at which the human body begins to feel negative health impacts from heat, and was therefore selected as the baseline temperature for this exercise. The number of days per year where the ambient air temperature in Snohomish is 90°F or above has been increasing in recent years– in 2019, there was one 90°F day, 2 in 2020, and 8 in each 2021 and 2022. These numbers are expected to increase in the future, as discussed in more detail in *Section 3: Climate Projections for the City of Snohomish*. The results of the urban heat island analysis for 95°F, 100°F, and 105°F days are included in Figures 2.8, 2.9, and 2.10.

Figures 2.8, 2.9, and 2.10 identify several hot spots. Snohomish High School, located along Avenue D between 5th and 7th Avenue, has the highest ratio of surface temperature to ambient air temperature on a day with average humidity. On a 90°F day, the surface temperature at the high school is approximately 105°F. This is due to the ample impervious cover on the high school property, including two synthetic turf fields, which are known to contribute to the urban heat island effect (Myrick 2019). Other hot spots include the Safeway and Haggen grocery stores near the intersection of Avenue D and 13th Ave, the Snohomish Station shopping plaza on Bickford Ave, and the area in the southeast corner of the City bounded by First Street, Second Street, and Lincoln Ave. On a 100°F day, aside from the identified hot spots, many areas in the city are actually 102°F or hotter, which is both unpleasant and potentially hazardous for residents and visitors.

Figure 2.10 contextualizes the felt temperature profile in Snohomish during the historic heat event that occurred in the Puget Sound region in late June and early July of 2021. During this event, a historic high air temperature of 105.6°F was observed in Snohomish. Figure 2.10 indicates that the actual temperature, especially in most residential and commercial areas of the City, was between 110°F and 125°F. During this event, at least 15 people died in Snohomish County, most of whom were 65 and older (WSDOH 2021). The risk of heat-related impacts and illness during this event was high to very high for most of the population, with elderly populations, infants and children under four, people who are overweight, and people with preexisting conditions at the highest risk (see *Section 2.4: Vulnerable Populations & Environmental Justice* for more information). Understanding where urban heat islands are located within Snohomish can help the City target interventions to lower the risk to the most vulnerable populations.

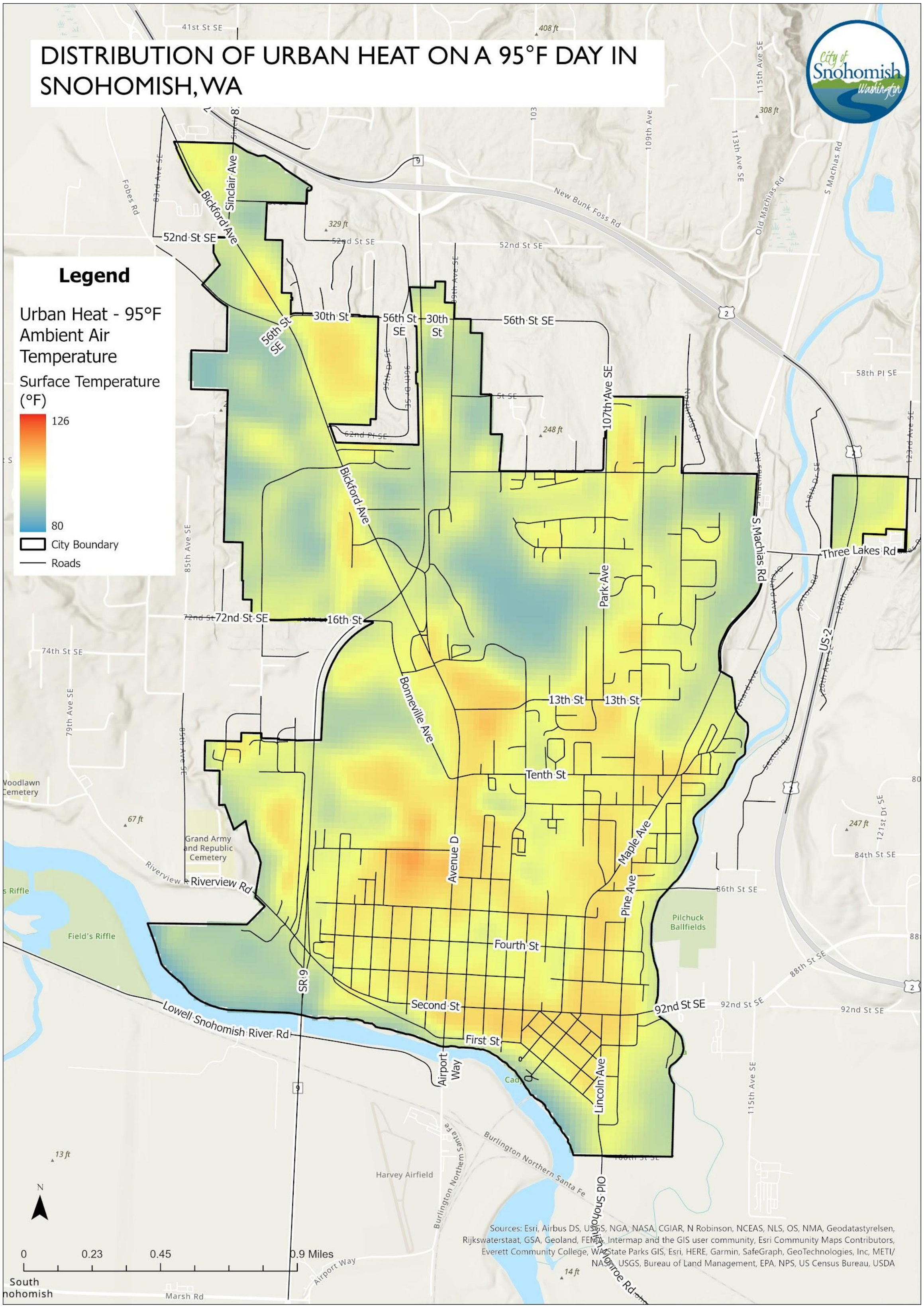


Figure 2.8: Distribution of Urban Heat on a 95°F Day in Snohomish, Washington.

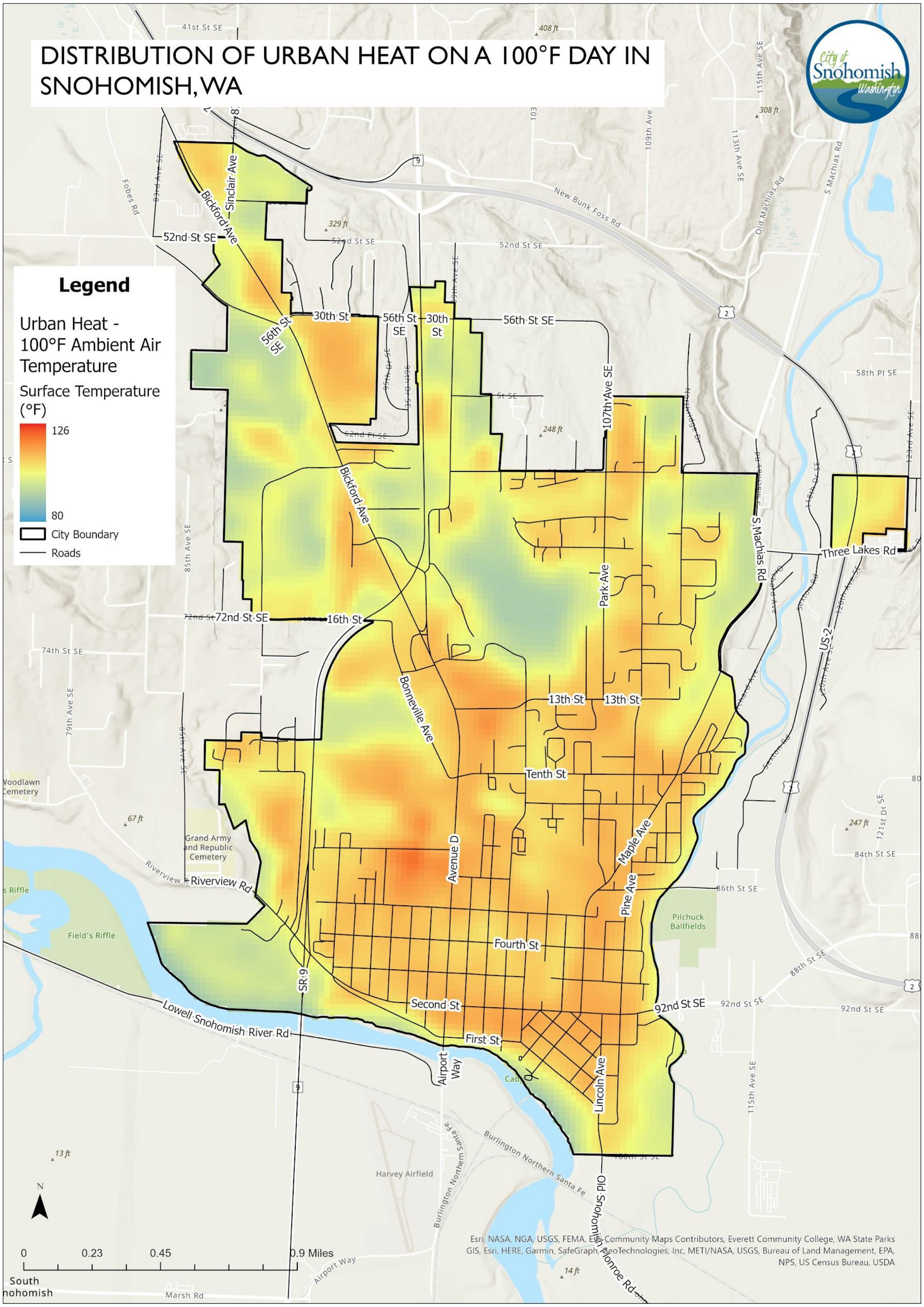


Figure 2.9: Distribution of Urban Heat on a 100°F Day in Snohomish, Washington.

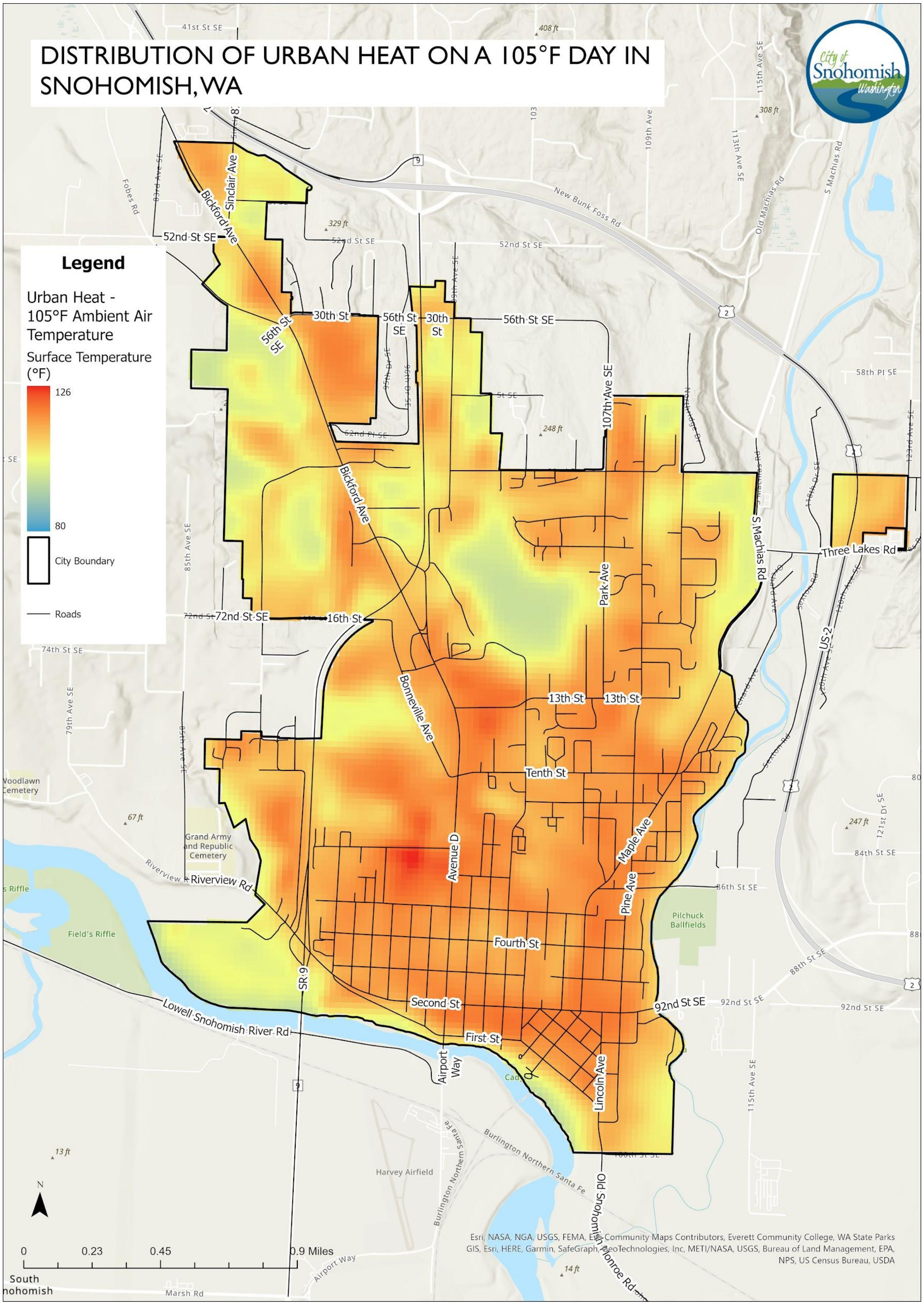


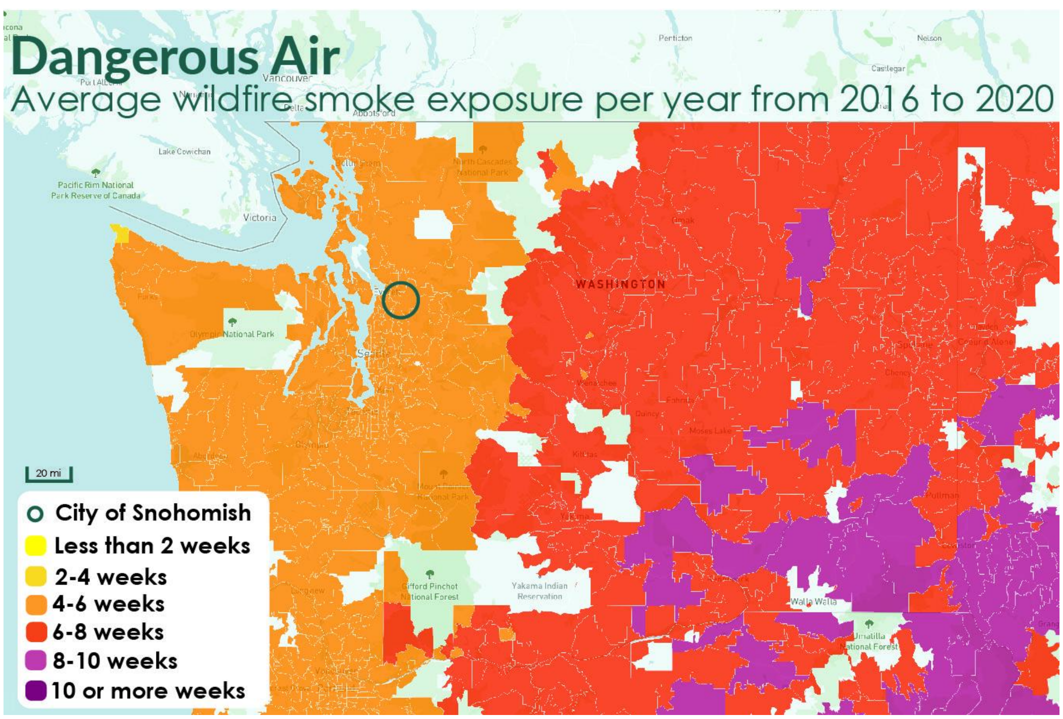
Figure 2.10: Distribution of Urban Heat on a 105°F Day in Snohomish, Washington.

2.3: Wildfire & Smoke

Over a century of fire suppression behavior across the Western United States has altered the natural and human-maintained cycle of frequent low- and moderate-severity wildfires. Historic wildfires tended to burn quickly and at low intensities while also increasing the landscape's fuel load (Hagmann et al. 2021). Hagmann et al. (2021) found that by the late 20th century, fire suppression behavior doubled the area likely to support high-severity wildfires, and reduced by half the area likely to support low-severity wildfires. Unfortunately, when coupled with climate change impacts, such as extreme heat and drought, the increased area for high-severity wildfires and the increased fuel load per area makes forests especially vulnerable to high-intensity wildfires. Throughout the remainder of the 21st century, extreme fire weather and wildfire are inevitable (Hagmann et al. 2021, p.2).

Wildfire impacts are felt both locally and indirectly. While Reid et al. found inconclusive results regarding the effects of particulate matter on age, the report did suggest those with pre-existing conditions, particularly cardiovascular and respiratory conditions, may be more sensitive to smoke exposure (2016).

According to Stanford University's Environmental Change and Human Outcomes Lab (2021), Snohomish experienced an average of 21 days of wildfire smoke per year between 2009-2013 and an average of 31 days of smoke per year between 2016 to 2020. This represents a 50% increase in average days of smoke per year in the City of Snohomish.



Source:https://www.capradio.org/articles/2021/09/28/dangerous-air-we-mapped-the-rise-in-wildfire-smoke-across-america-heres-how-we-did-it/

Figure 2.11. Average Wildfire Smoke Exposure Per Year from 2016 to 2020 **(**Stanford 2021)

2.4: Vulnerable Populations & Environmental Justice

To write effective policy, it is important to acknowledge that the impacts outlined in this section will affect the residents who call Snohomish home, with the potential to negatively impact their day-to-day life, health, finances, homes, and more.

While all these climate events have the potential to impact the city as a whole, certain individuals and places are at greater risk of being affected and likely to be more severely impacted than others. We define these collective groupings of individuals as vulnerable populations. The US Environmental Protection Agency identifies three factors that help determine the vulnerability of a particular population to climate impacts (EPA 2017):

1. **Sensitivity** refers to the degree to which people or groups are affected by a stressor such as higher temperatures.
2. **Exposure** refers to physical contact between a person and a stressor.
3. **Adaptive capacity** refers to an ability to adjust to or avoid potential hazards.

Certain populations have greater sensitivity, more exposure, and/or less adaptive capacity to adjust to climate impacts, which makes them more vulnerable to climate risks. The City of Snohomish's current Comprehensive Plan does not emphasize planning for the most vulnerable populations in the community. We recommend that the City consider vulnerable populations in future planning and in the 2024 Comprehensive Plan update.

In addition, we recommend the City of Snohomish use an environmental justice lens throughout each step of the planning process. The EPA defines environmental justice as "the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies" (EPA 2023). The City can work towards the goals of every resident enjoying "the same degree of protection from environmental and health hazards" and "equal access to the decision-making process to have a healthy environment in which to live, learn, and work" (EPA 2023). Keeping these goals in mind will help the City ensure equitable planning for all residents when preparing for future climate impacts. Many of the suggestions in the "Draft Goals and Policies for Climate Element" Section incorporate language that stems from an environmental justice lens.

To develop inclusive community outreach and effective policies, it would be ideal for the City to locate the precise locations where vulnerable populations exist. In our efforts to map the locations of specific populations, we discovered that:

- Limited 2020 US Census data exists at the block group level in the City. The closest block group level data that could potentially be relevant in understanding the locations of vulnerable populations include: "Race," "Occupancy Status," and "Group quarters population by major group quarters type" (US Census Bureau 2020).
- A broader array of data is available at the Snohomish County level, but in some cases, County data may not be representative of local conditions.

- The Census blocks groups and Census tracts do not align directly with the City of Snohomish Boundary; thus, the US Census data are not precisely representative of the city itself.

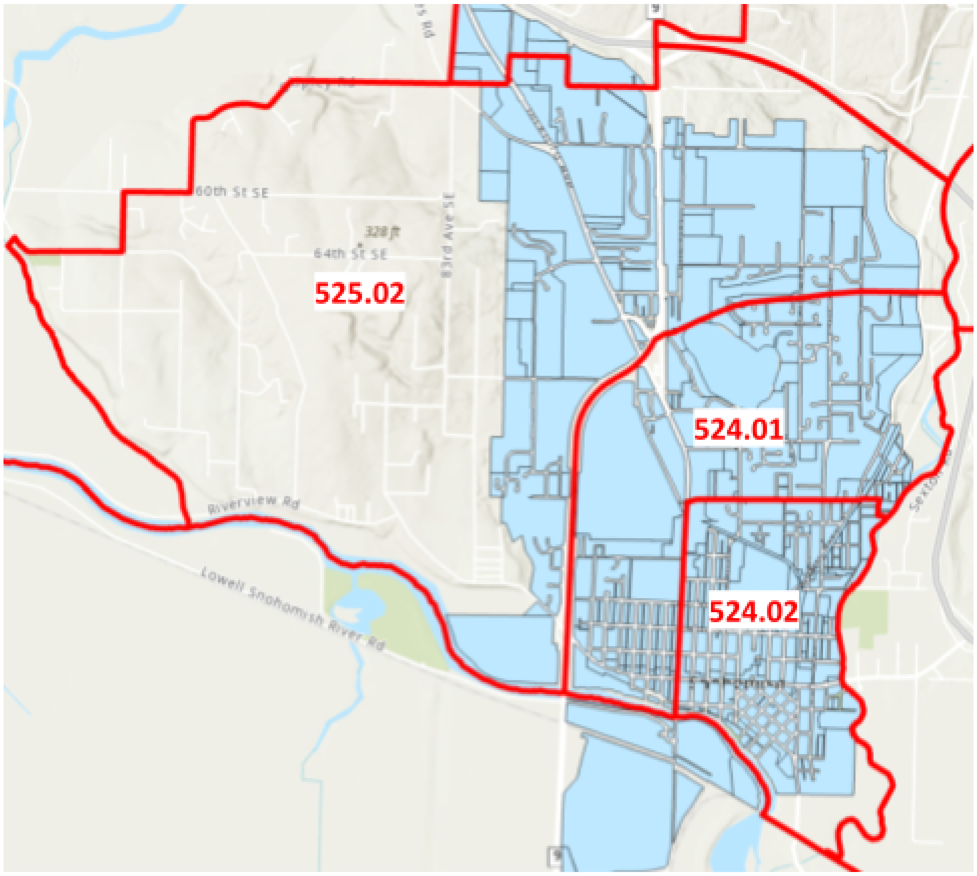


Figure 2.12: 2020 US Census tracts (red boundaries) overlaid on City of Snohomish boundary (blue area) (U.S. Census Bureau 2020)

Due to these factors and due to the fact that populations consistently move, we chose first to define the *characteristics* of vulnerable populations. We chose to use Snohomish County-level data to provide a more accurate snapshot and to leave room for the potential movement of populations. The EPA has identified seven primary populations of concern when considering the risks of climate change (EPA 2017). These populations of concern are listed below along with accompanying Snohomish County data, as available.

Populations of Concern:

- Older adults
    - Likely to "have greater sensitivity to heat and contaminants, a higher prevalence of disability or preexisting medical conditions, or limited financial resources that make it difficult to adapt to impacts" (EPA 2017)
    - 14.4% of the Snohomish County population is age 65 and over (U.S. Census Bureau 2020)

- People with disabilities
    - Likely to be very vulnerable during extreme weather events, as emergency response plans often do not specifically accommodate them (EPA 2017)
    - 11.6% of the Snohomish County population is disabled (U.S. Census Bureau 2020)
- People with chronic medical conditions
    - Likely especially vulnerable during extreme heat, especially if taking medications that make it challenging to regulate body temperature or using medical equipment that relies on power (EPA 2017)
    - Census data do not identify populations with medical conditions; please see discussion of populations of concern, below.
- Children
    - Likely "vulnerable to many health risks due to biological sensitivities and more opportunities for exposure (due to activities such as playing outdoors)" (EPA 2017)
    - 18.5% of the Snohomish County population is age 14 and under (U.S. Census Bureau 2020)
- Pregnant women
    - Vulnerable to extreme heat and other extreme events, like flooding (EPA 2017)
    - 5.4% of women in Snohomish County had a birth in the past 12 months (U.S. Census Bureau 2020)
- Communities of color, low-income people, immigrants, and limited English proficiency
    - Likely "face disproportionate vulnerabilities due to a wide variety of factors, such as higher risk of exposure, socioeconomic and educational factors that affect their adaptive capacity, and a higher prevalence of medical conditions that affect their sensitivity" (EPA 2017)
    - 44% of Snohomish County is non-white and 7.1% is below the poverty level (U.S. Census Bureau 2020)
- Certain occupational groups like outdoor workers, paramedics, firefighters, transportation workers
    - Likely exposed to extreme heat and vector borne illnesses (EPA 2017)
    - The primary source of industry, occupation, and class of worker data the American Community Survey (ACS). They are also collected on other surveys, such as the Current Population Survey, and on older decennial censuses (U.S. Census Bureau 2020)

Second, we conducted an online search to find locations where these populations of concern are likely to live or congregate, and overlaid these with our urban heat island analysis map (from *Section 2.2: Urban Heat Island Analysis*) to create Figure 2.13 (below). We chose to overlay these locations with the urban heat island map because urban heat is a location-specific stressor.

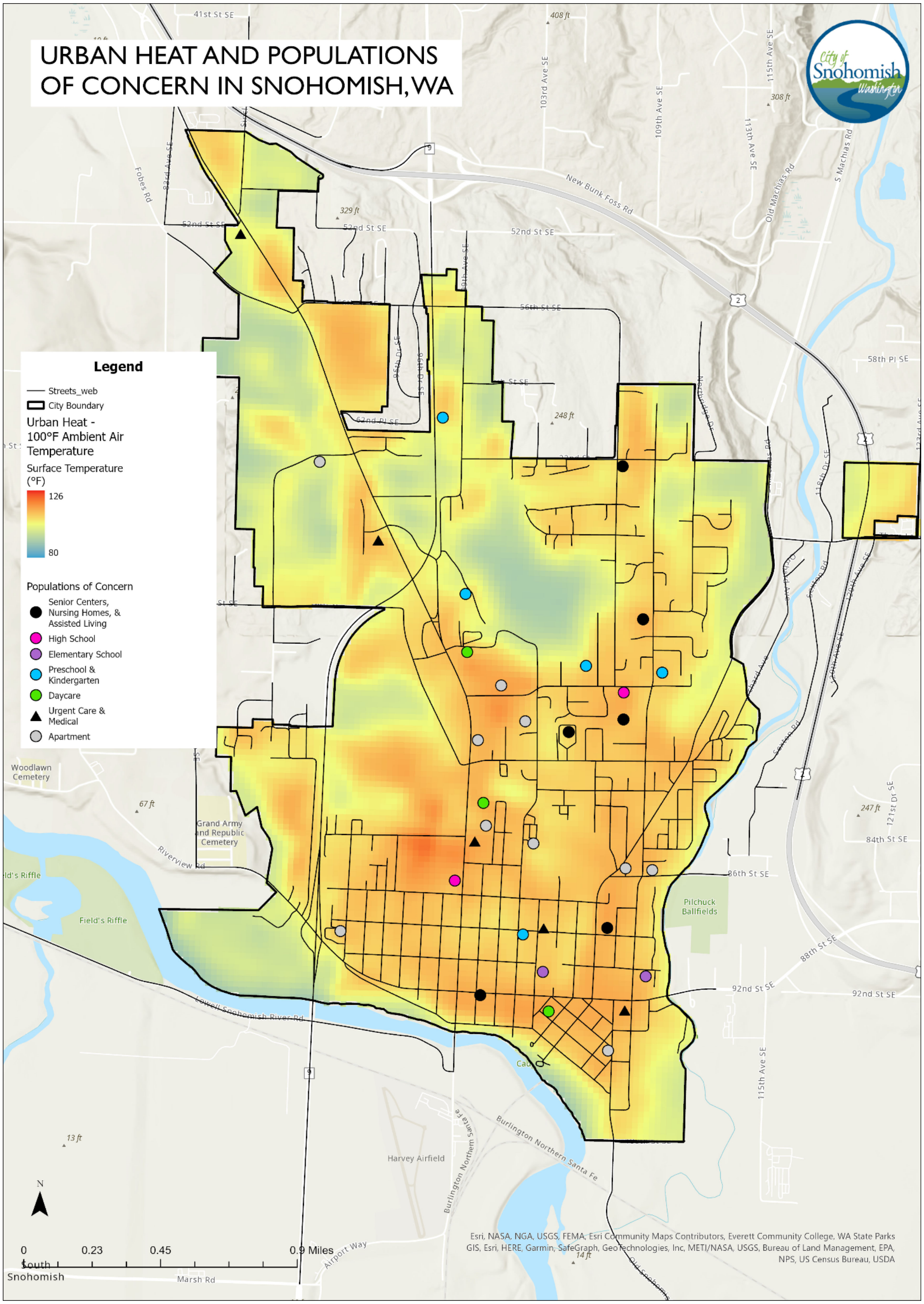


Figure 2.13: Urban Heat & Populations of Concern in Snohomish, WA

Section 3: Climate Projections for the City of Snohomish

This section analyzes future projections for the key climate hazards of extreme heat, extreme precipitation, flooding, and drought in the City of Snohomish. The projections are compiled from the University of Washington (UW) Climate Impacts Group's *Climate Mapping for a Resilient Washington* webtool.

Introduction

Using historical data from 1980-2009, the UW Climate Impacts Group webtool models a range of potential future outcomes for different climate change conditions, timeframes, and relative greenhouse gas (GHG) emission concentrations in the atmosphere. This report distills the data compiled at the Snohomish County scale and also considers hydrologic models on sections of the Snohomish and Pilchuck Rivers that abut the boundaries of the City. The UW Climate Impacts Group recommends that jurisdictions use county data because available projections are not as precise at the city scale. This discrepancy may lose the variation of climate impacts that can be seen at the county-level. The UW Climate Impacts Group data is presented entirely in probabilities based on mean model outputs, and is a compilation of multiple models for each hazard. The UW Climate Impacts Group identifies seven hazard categories: Drought, Extreme Heat, Extreme Precipitation, Flooding, Reduced Snowpack, Sea Level Rise, and Wildfire. Through extensive exploration of the webtool, we determined that reduced snowpack, sea level rise, and wildfire are not considered direct hazards facing the City of Snohomish, while drought, extreme heat, extreme precipitation, and flooding are extremely relevant.

Methodology

The four key climate-induced hazards (drought, extreme heat, extreme precipitation, and flooding) are identified as the most relevant for the City because they are all likely to increase in frequency and intensity in the models for different time scales and emissions scenarios. Two time scales are used to scope the future conditions: 2030-2049 (hereafter referred to as "short term") and 2060-2079 (hereafter referred to as "long-term"). The shorter time frame was chosen to reflect the 2024 Comprehensive Plan horizon, whereas the longer time frame was selected to align with the lifespan of a current adult resident in the City. Along with the two timescales, we chose to examine two emissions scenarios to illustrate the resulting warming from different levels of greenhouse gasses in the atmosphere in the future. The emissions scenarios are constructed using internationally-recognized models known as

Representative Concentration Pathways (RCP).[12] For this analysis, RCP 4.5 (low-emissions scenario) is compared to RCP 8.5 (high-emissions scenario) to demonstrate a broader spectrum on the range of future climate conditions and the impact climate mitigation can have on reducing future hazards. Finally, we connect the projections to key sectors in the City that may be affected by the climate impacts. All climate projections compiled from the UW Climate Impacts Group can be found in *Appendix B: Snohomish Climate Projections.*

Analysis

The contents of Table 3.1 show the climate change indicators and their associated hazards that are projected to have the greatest divergence across emissions scenarios and time scales.

Table 3.1: Prioritized hazards, select climate indicators, and median projections over two time scales. *(Source: University of Washington Climate Impacts Group)*

Hazard Indicator	**By Year**	**Low-Emissions Scenario**	**High-Emissions Scenario**
Extreme Heat Increase in days of Humidex above 90°F	2049	6.7 days	8.5 days
	2079	14.1 days	32.7 days
Drought Percent decrease in June-Sep. streamflow of Snohomish River	2049	-32%	-38%
	2079	-51%	-61%
Extreme Precipitation Percent increase in rain magnitude of a 25-year storm	2049	No data	8%
	2079	8%	17%
Flooding Return interval of 25-year peak streamflow of Snohomish River	2049	9.7 years	10.5 years
	2079	4.7 years	5.1 years

[12] Representative Concentration Pathways (RCP) are used internationally, such as by the United Nations' Intergovernmental Panel on Climate Change (IPCC), to model potential future climate scenarios based on models for future concentrations of GHG. The IPCC defined four pathways (RCP 2.6, 4.5, 6.0, and 8.5) to forecast different climate futures depending on GHG trajectories. The UW Climate Impacts Group uses RCP 8.5 to show a higher emissions scenario and RCP 4.5 to show a low emissions scenario (though IPCC used RCP 4.5 as an intermediate emissions scenario in their 2014 report). Between 2041 and 2060, RCP 4.5 is likely to result in 2.0°C of estimated warming and RCP 8.5 is likely to result in 2.4°C of estimated warming. While RCP 4.5 is likely to lead to a global temperature increase between 2.1-3.5°C between 2081-2100, RCP 8.5 is likely to result in global warming between 3.3-5.7°C. Small differences in global temperatures can have large impacts that can be felt on the local scale. The two emissions scenarios are compared to reflect how mitigating GHG emissions now can prevent more drastic climate change impacts.

Extreme Heat

Extreme heat is defined as days where the Humidex, or the felt temperature (a combination of ambient temperature and humidity), is above 90°F. This temperature is the threshold when people experience more adverse health effects and may suffer from heat exhaustion. This is especially relevant to vulnerable communities who are disproportionately burdened by health issues and lack of resources to escape extreme heat and cool down.

Figure 3.1: Climate Nexus of Extreme Heat in Snohomish

The City is projected to experience impacts related to extreme heat over the short term which will have greater impacts in the long term. As referenced in Table 3.1, the City will be affected by high air temperatures and as well as felt Humidex values above 90°F. The potential for extreme heat to be felt for over one month of the year raises concerns for many sectors in the City (Figure 3.1). Our Urban Heat Island analysis indicates that certain areas of the City, such as the Safeway and the high school, will feel the hottest on a day of extreme heat.

Drought

The City of Snohomish is susceptible to drought conditions on the local scale and will likely also experience the upstream effect of drought conditions from the higher elevations within Snohomish County. The Snohomish River watershed is partially fed by snowpack and reduced snowfall will reduce summer streamflow and riparian ecosystems. While the direct impacts of wildfire within the City are projected to be minimal, Snohomish is within the Wildland-Urban-Interface (WUI) and should minimize the amount of combustible materials adjacent to and within developed areas during periods of drought (Figure 3.3).

Figure 3.2: Climate Nexus of Extreme Drought

Extreme Precipitation

As shown in Table 3.1, total precipitation in the City is expected to increase. An increase of precipitation may impact erosion of slopes and reuptake capacity of soils. However, the projections indicate that late summer precipitation will decrease, implying an increase in seasonal events with wetter winters. The magnitudes (amount of precipitation falling in a given event) of both two-year and twenty-five-year storm events will increase as well, showing that precipitation will be less consistent and will fall in more concentrated, intense events. Precipitation will increasingly fall as rain instead of snow as temperatures increase.

Figure 3.2: Climate Nexus of Extreme Precipitation in Snohomish

According to the UW Climate Impacts Group, Extreme precipitation is expected to impact many sectors (Figure 3.2). Extreme precipitation, in conjunction with flooding, could impact the City's tourism industry, particularly in Historic Downtown Snohomish and the local businesses along First Ave that are parallel to the Snohomish River. The critical areas in the City which include steep slopes may also be affected by the increases in seasonal events and severe storms that lead to soil erosion.

Flooding

The Snohomish River is a wide and slow river that is tidally influenced. Flooding is already a hazard experienced by the Snohomish community and is documented on the riverwalk. Climate projections indicate increased flood frequencies tied to the greater frequencies of extreme precipitation events. Flooding is a hazard to many sectors and, in Snohomish, will particularly impact ecosystems and economic development, as the historic commercial core is adjacent to the Snohomish River (Figure 3.4). Zoning and development considerations, like adapting buildings to withstand flooding or not allowing new buildings in the floodplain, will help mitigate damage from flood waters.

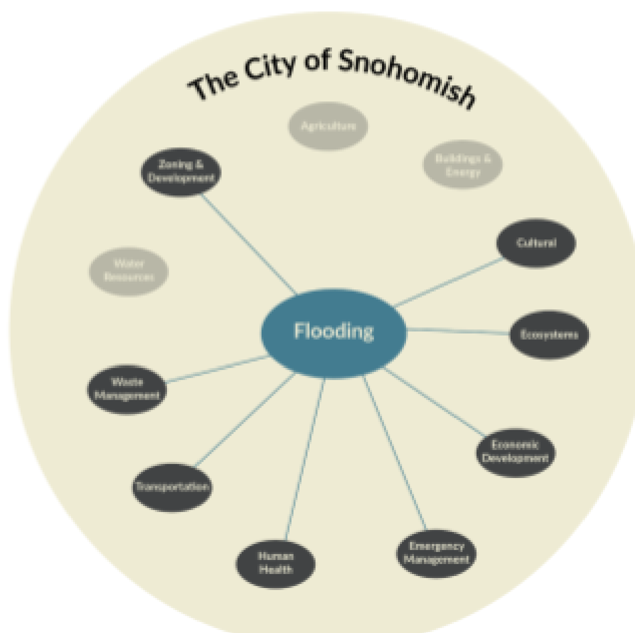


Figure 3.4: Climate Nexus of Flooding

Cascading Impacts

While less predictable, it is important to keep the interrelations of these indicators and hazards in mind. The combination of extreme heat and drought would increase wildfire risk and decimate ecosystems. Wildfire is another consideration with the combination of increased heat and drought conditions, but not an immediate threat to the City. Smoke dispersion is directly tied to weather patterns and is unpredictable, but frequency of wildfire will increase and therefore smoke days will likely increase as well.

Takeaways

As illustrated in Figure 3.5, extreme heat, extreme precipitation, flooding, and drought have overlapping effects on key sectors in the City and region. Compounding events, defined by multiple failures across sectors that can amplify risk or cause cascading impacts, may also occur. The connections between climate indicators and hazards illustrates the need for a holistic approach to adaptation planning.

The analysis of future projections also highlights the importance of reducing emissions in order to decrease the probability of more severe climate hazards from occurring in the City. Climate hazards will still occur under a low-emissions scenario, emphasizing the need for adaptation measures as well.

Figure 3.5: Synthesis of Key Hazards and Impacted Climate Nexus Sectors.

Section 4: SWOT Analysis of Climate Change Driven Risks to Assets

Introduction

Previous sections have covered current and future hazards; now, this section pivots to identify critical assets in the City of Snohomish, then attempts to prioritize these assets based on their vulnerability to climate change impacts. This is done based on our ranking of key assets in a number of categories, and then ranking them relative to the likelihood of an event vs. the severity of a disruption to the asset.

Threats

Flooding and drought as a result of increased seasonality due to climate change have the potential to be extremely disruptive to assets critical to the city. With 25 year floods becoming more common and June-September streamflows being up to 61% lower than current levels, the seasonality has far-reaching impacts (Raymond and Rogers 2022). This has cascading impacts that include increased river flow creating conditions likely to erode critical shoreline as well as disturb ecosystems critical to endangered species. Droughts also bring about conditions more favorable to wildfires, which pose no direct threat to the city, but it can be inferred that these wildfires will lead to an increased number of smoke days in Snohomish. There is also a risk of the city's combined stormwater and sewer system overflowing, causing wastewater leaks.

Flooding endangers the most consequential assets. Flooding itself leads to wetland loss, erosion of the shoreline, and property damage. Increased temperatures, drier summers and warmer winters lead to less snowpack and more rainfall, which contributes to increased and more variable streamflow. This will especially endanger lengths of the Snohomish River shoreline, as well as aquifer recharge areas, with the Pilchuck River and Blackmans Lake shorelines at less risk. Bridges, roads and parks along these rivers will become more likely to flood more regularly, as will critical infrastructure such as the Wastewater Treatment Plant and stormwater catchment basins.

Summers are becoming warmer. The number of Humidex days above 90 degrees Fahrenheit is projected to rise by 2.5 (low projection) to 12.5 (high projection) by 2049 (Raymond and Rogers 2022). On days in the 80s Fahrenheit, those with Heat-Related Illnesses (HRIs) are told to exercise caution, and on days in the 90s Fahrenheit they are considered in danger (NOAA 2023). Median high temperatures are expected to reach 3.4 degrees Fahrenheit higher than current levels by 2049.

Those with health conditions, the elderly, and those who work outdoors are the most at-risk, although higher temperatures, combined with wildfire smoke, will also suppress tourism and outdoor activities.

Summer droughts also lead to increased risk of wildfires, which mainly threaten Snohomish through creating unsafe atmospheric conditions. Wildfire likelihood in the areas around the city is expected to rise by 4% by 2049 (Raymond and Rogers 2022).

Strengths
Snohomish's downtown core is walkable and compact. It is a prime location for new mixed-use development, community events, and expansion of public transit. The city has strong employment in the school district and public services. Fortunately, the main residential and commercial areas are outside of the floodplain. Due to its steep topography, the infrastructure of this area of the city is not vulnerable to flooding.

Snohomish plays host to multiple organizations that emphasize climate change action. These include Kiwanis, the Boys and Girls Club, and the Snohomish Youth Council. Community centers and schools with air conditioning will be valuable places of shelter for people with heat-related illnesses during heatwaves. Although they are also vulnerable, Snohomish's wetlands can help to mitigate flooding effects.

A brief list of the assets identified in Snohomish are as follows:

- Roads
- Bridges
- Bus Route
- Harvey Airfield
- Avenue D
- Downtown Business District
- Residential properties
- Wastewater Treatment Plant
- Stormwater Infrastructure
- Human Health
- Carnegie Library
- Senior center
- Parks
- Medical center
- Public schools
- Snohomish River
- Pilchuck River
- Blackmans Lake
- Mature Trees
- Wetlands
- Salmon population

Weaknesses
Snohomish has a few points that make it particularly vulnerable to threats. Snohomish has a population older than that of the county, meaning that these populations will likely be very sensitive to increases in hot days and smoky days. The limited number of buildings with air conditioning also make this a difficult situation to deal with, and limits the typical resident's access to adaptive measures.

The City also has three major shorelines– the Snohomish and Pilchuck Rivers as well as Blackmans Lake– all of which have banks that are already seeing erosion as a consequence of flooding that is only going to worsen. The erosion of these shorelines endangers ecosystems and valuable carbon sinks that could help reduce the city's carbon emissions. Erosion of these shorelines could also directly damage property and have already been an issue in some of the parks that run along the Pilchuck River. These bodies of water all have water quality issues that further endanger the vulnerable wildlife populations that rely on them (Ecology 2022).

Snohomish's population is heavily car-dependent, as workers in the city live in areas with better rental housing opportunities, and Snohomish's residents typically commute to better employment opportunities outside the city. This use as a bedroom community highlights the lack of housing diversity in the city, especially a shortage of affordable rental housing. This leads to a large portion of the community depending on car-based commuting, either into or out of the city, twice daily. Community Transit serves the city with limited connections to Lynnwood (Ash Way P&R), Monroe, and Gold Bar. This means that the flow of traffic through Snohomish is high and often leads to congestion along major thoroughfares such as Avenue D or Second Street. Many of the hazards have potential to worsen this traffic burden given the risk to infrastructure.

Economically, the city depends on revenue from sales tax and tourism, which can fluctuate. This fluctuation will worsen with natural hazards, high temperatures, worsening urban heat islands, and more frequent smoke days deterring visitors.

Although its housing and commercial areas are outside the floodplain, the same cannot be said for critical infrastructure such as its wastewater treatment plant. The historic Downtown Bridge is also in the floodplain.

Opportunities

In Phase B of Project Development, we will account for the Department of Commerce guidance, analyze the current Comprehensive Plan for gaps in environmental hazard mitigation, draft new climate goals and policies, and develop our “Menu” of adaptation and mitigation strategies.

Tools and Methods

We prioritized Snohomish’s environmental risks and concerns through the use of a risk matrix. We divided the assets into Community, Environment and Economy, and researched the hazards most likely to affect each asset, based on the hazard’s frequency and the asset’s adaptive capacity. We also accounted for the increasing severity of hazards, such as flooding, with “20-year events” becoming more and more frequent.

The C40 Rapid Risk Assessment is a framework intended for cities to assess the future spatial risk, and risk to inhabitants, posed by climate change. The Climate Impacts Group at the University of Washington provides a variety of web tools that model future river floodplain, atmospheric, and temperature conditions. We will give a brief description of each of the analytical tools that we used to accomplish a well rounded risk assessment.

Asset Categorization Tool

This tool is used to encourage the team to think of assets along three different dimensions: Environment, Community, and Economic. This encouraged us to think of the community from an approach that prioritized assets in each category rather than categorized one group of assets over another. We defined the assets as being in the categories based on the C40 sector classification system.

Itemized Asset Hazard Index

This tool is a way to achieve a rough “risk” rating for each asset. The assets are listed, sometimes as sublistings of a category of assets, and then are assessed based on the categories Exposure, Impact, Sensitivity, and Adaptive Capacity, the combination of which are weighed in order to create a rough risk ranking. The rankings were tiered between Low, Medium, High, and occasionally mixed meaning that this category can have many variables to account for at varying risk levels. The rankings of High, Medium, and Low for the categories were on a qualitative rubric based scale.

Table 4.1: Individual Risk Rating

High	Category is of significant concern and is likely to be a root cause of disruption given the event of said hazard. Plays a central role in risk calculation.
Medium	Category is of some concern and could be a cause of disruption given the event of hazard. Plays some role in risk calculation.
Low	Category may or may not be a cause of disruption in the event of hazard occurrence. Little role in risk calculation.
Mixed	Asset has varied applications of these categories.

The cumulative risk rating is calculated on a similar rubric:

Table 4.2: Cumulative Risk Rating

High	Given a category rating of "High" in two or more categories, this asset is at high risk of damage and will likely cause massive disruption to the city.
Medium	Given a category rating of at least "Medium" in three or more categories, this asset is at risk of some manageable damage and will cause some disruption.
Low	A maximum of two ratings of at most "Medium." This asset either has little chance of being damaged or will be more of an inconvenience than a disruption.

It is worth noting that this process would inherently be much more accurate with community feedback as some of these assessment categories can be subjective or even political but we were unable to engage the community due to substantial time constraints. The intent is for the reader to be able to clearly see the thought process of the team when determining the risk factor associated with which assets.

Risk Matrix

The risk matrix, *Appendix C: Risk Matrix for the City of Snohomish*, is a tool used to visualize and prioritize risks relative to each other. In our case, we took many of the risks identified and placed them on a matrix with Likelihood on the Y axis and Severity on the X axis. The placement along the X axis is a rough calculation of the Adaptive Capacity, Impact, and Sensitivity categories while the placement along the Y axis is a combination of Exposure and the likelihood of that hazard to occur according to our analysis of data compiled by UW's Climate Impact Group. Risks on the top right are the top priority and the bottom left would be of least concern.

Section 5: Climate Change Regulatory Framework for the City of Snohomish

Objective

The purpose of this report is to review climate adaptation and mitigation regulations, bills, plans, and relevant documents at the state, regional, and county levels. The documents are analyzed within key sectors to frame the policy recommendations for the City of Snohomish (hereafter the City) and identify ways in which the City can contribute to or align with the broader goals of the state, region, and county.

Background

The University of Washington Climate Planning Studio reviewed 11 climate change policies, plans, and regulations: five bills and acts from Washington State, two plans and relevant documents from the Puget Sound region, and four plans from Snohomish County (please reference the Methodology section for the specific policies and plans we reviewed).

The University of Washington Climate Impacts Group's *Climate Mapping for a Resilient Washington* webtool (Raymond and Rogers 2022) and the Washington State Department of Commerce's Draft Model Climate Element (Department of Commerce 2023) both identify 11 sectors for addressing climate change: Agriculture & Food; Buildings & Energy; Cultural Resources & Practices; Economic Development; Ecosystems; Emergency Management; Health & Well-being, Transportation (roads, bridges, multimodal); Waste Management; Water Resources; and Zoning & Development. We categorized the relevant goals from each climate policy or plan under these sectors. We added Greenhouse Gas (GHG) Emissions Reductions and Cross Jurisdictional / Regional Collaborations as additional categories to better encompass the breadth of goals and regulations. We also identified whether the goals support mitigation and/or adaptation strategies.

We identified the following sectors to be the most relevant for the City: Emergency Management, Greenhouse Gas (GHG) Emissions Reductions, Buildings & Energy, Ecosystems, Health & Wellbeing, Transportation, Water Resources, Cultural Resources & Practices, and Economic Development. *Appendix D: Regulation Summaries* contains the complete analysis of each of the eleven documents.

Emergency Management

As the Department of Commerce points out in its recent draft Climate Element Planning Guidance, emergency management and hazard mitigation planning is an excellent place to find synergies and overlap with building climate resilience. The Snohomish County Hazard Mitigation Plan (HMP) is perhaps the most relevant plan out of those reviewed for preparing the City for natural disasters that climate change will cause or exacerbate. The County is responsible for protecting the health, safety, and welfare of the community by reducing risks associated with natural hazards. The HMP also includes goals related to protecting life, property, and infrastructure against hazards such as flooding, earthquakes, landslides, fires, and other natural and anthropogenic disasters and threats. Strategies to attain these goals are broad, including retrofitting, flood proofing, emergency preparedness programs, regional coordination, and building resilient communities. In addition to identifying major hazards and goals, the plan also includes a brief description of how climate change will exacerbate hazards. Some of these descriptions of climate change impact are underdeveloped and lack key impacts (see *Appendix E: Snohomish County*

Hazard Mitigation Plan - Climate Change Summary). For example, extreme heat is barely mentioned as a threat, despite its high potential for health impacts. However, the County is currently working on a Climate Change Vulnerability & Risk Assessment[13], to be included in its 2024 Comprehensive Plan update, which should better identify climate change impacts.

The City is required to prepare an annex to the County's HMP to include more specific hazard risk assessment and mitigation strategies and is currently in the process of an update. The City's most recent (2015) annex to the HMP includes initiatives to retrofit and flood proof at-risk structures and infrastructure, stabilize slopes, build redundancy into key infrastructure, build resilience into vulnerable areas, educate the public, and coordinate with other agencies and jurisdictions. In its annex update, the City should take the opportunity to refine and expand upon the County's identified climate change impacts by incorporating climate projections, downscaled to the City. The City can then develop hazard mitigation initiatives and strategies that more fully incorporate climate change resilience. It is expected that climate change impacts will be more thoroughly identified by the aforementioned update to the County's Comprehensive Plan, and the City should coordinate with the County to align its HMP annex.

Aside from the HMP, there are other plans and legislation that provide guidance, support, and opportunities to the City for building hazard and climate resilience. The County Comprehensive Plan and the Puget Sound Regional Council's (PSRC) Vision 2050[14] mention the importance of improving the County's preparedness to respond and adapt to climate change, as well as designating and protecting areas that are prone to flooding and geologic hazards. Washington State's Senate Bill 5126 (SB 5126) created the Natural Climate Solutions Account to invest in natural projects that increase the resilience of the state's ecosystems, including reducing flood risk and incorporating green stormwater infrastructure. For more information on the State's Natural Climate Solutions Account, as well as other accounts created under Senate Bill 5126 please see Table 5.1. The Puget Sound Clean Air Agency (PSCAA) provides the region with access to up-to-date air quality monitoring and advice to reduce risk during high smoke/pollution days. The City should use these resources to ensure regional consistency and alignment, as well as reduce costs by accessing available funding, and utilizing regional educational materials in building its own climate resilience plans.

Table 5.1: Descriptions of the Climate Investment Account, Climate Commitment Account, Natural Climate Solutions Account, and Carbon Emissions Reduction Account.

The **Climate Investment Account** is a fund created by Washington's Senate Bill 5126, the Washington Climate Commitment Act, from the auction of businesses' unused carbon emission allowances. It creates a cap-and-invest system by encouraging businesses which do not use all their carbon emission credits to sell those credits to other businesses. The program started January 1, 2023. The first auction occurred in

[13] The County's risk assessment will identify community assets, potential climate change driven impacts to assets, and assess vulnerability to impacts based on asset exposure, sensitivity, and adaptive capacity.

[14] PSRC's Vision 2050 is the shared regional plan for sustainability and equity; a call to action to address long-term regional challenges, including racial and social inequality, climate change, housing affordability, and imbalance of jobs and housing throughout the region. The Council's influence extends through transportation funding, comprehensive plan certification, growth strategy and target setting, and the development and implementation of regional planning frameworks.

February 2023 and generated $300 million (Ecology 2023) for "projects and programs that achieve the goals of the greenhouse gas emissions cap and invest program" (RCW 70A.65.250). More information on the account is available here: [RCW 70A.65.250: Climate investment account. (wa.gov)](). The Account allocates 75% of funds to the Climate Commitment Account and 25% of funds to the Natural Climate Solutions Account. Additionally, the Climate Emissions Reduction Account and Climate Investment Account will direct 35-40% of investments to direct benefits to vulnerable populations to reduce environmental burdens and disparities through an environmental justice assessment. While the Department of Ecology has not yet released a statement on how entities can pursue funds within the Climate Investment Account, we recommend the City monitor the Department of Ecology's website for news related to the Natural Climate Solutions Account, Climate Commitment Account, and Carbon Emissions Reduction Account as potential funding sources for climate mitigation and adaptation work. More information on the status of the Department of Ecology's cap and trade auctions and market is available here: Auctions and market - Washington State Department of Ecology (Ecology 2023).
The **Climate Commitment Account** (RCW 70A.65.260) is an account that receives 75% of funds from the Climate Investment Account, established under Senate Bill 5126. The funds are intended to be used to invest in projects, activities, and programs in Washington state that reduce and mitigate the impacts from greenhouse gas emissions. Such activities include increasing energy efficiency of industrial facilities, retrofitting buildings, and electrifying new residential and commercial buildings. This is relevant to the City of Snohomish because this report forecasts the City of Snohomish's largest carbon dioxide equivalent emissions to come from residential energy (see: "1.3: 2022-2044 GHG Emissions Forecast" from *Section 1: Greenhouse Gas Emissions Analysis for the City of Snohomish*). This account could be a viable funding source for the City to program building retrofitting. More information on the account is available here: RCW 70A.65.260: Climate commitment account. (wa.gov).
The **Natural Climate Solutions Account** is an account that receives 25% of funds from the Climate Investment Account, established under Senate Bill 5126. The funds are intended to be used for projects that "increase the resilience of the state's waters,

forests and other vital ecosystems to the impacts of climate change," conserve forestlands, increase carbon storage potential, invest in clean water and stormwater infrastructure, "reduce flood risk and restore natural floodplain ecological function," and preserve or increase carbon sequestration" (RCW 70A.65.270).

This account is relevant to the City of Snohomish because the City, acting independently or in collaboration with other small cities, may be able to pursue funds from this source to prepare for many of the natural hazards discussed in *Section 2: Existing Climate Impacts for the City of Snohomish* and *Section 3: Climate Projections for the City of Snohomish* of this report.

More information on the account is available here: [RCW 70A.65.270: Natural climate solutions account. (wa.gov)].

Senate Bill 5126 also established the **Carbon Emissions Reduction Account** which is intended to affect reductions in transportation sector carbon emissions through allowance auctions. The Department of Ecology deposited $127,341,000 in the Carbon Emissions Reduction Account after a 2023 auction, although the State anticipates this amount will drastically decrease every year after (RCW 70A.65.240).

These funds are intended to promote alternatives to single occupancy passenger vehicles and reduce single occupancy passenger vehicle vehicle miles traveled (VMT), encourage fuel economy standards and/or reductions in per mile emissions in vehicles, fund alternative fuel infrastructure and incentive programs. The funds are solely to be used for active transportation, transit programs and projects, and alternative fuel and electrification (RCW 70A.65.240)

We recommend the City of Snohomish monitor the Department of Ecology's webpage for status updates and more information on applying to receive Carbon Emissions Reductions funds. If the Department of Ecology makes funding available to cities or regional collaborations, the City of Snohomish may have an opportunity to apply for funds. There are several Transportation Element Goals and Policies within the Snohomish 2016 Comprehensive Plan that meet the criteria of this account (including, TR 3, TR 12, TR 13, TR 14, TR 15, TR 16, TR 17 and TR29) (City of Snohomish 2021).

More information on the account is available here: [RCW 70A.65.240: Carbon emissions reduction account. (wa.gov)].

Greenhouse Gas Emissions (GHG) Reductions

The City could consider existing state and regional policies to inspire decarbonization work, avoid fines, and avoid the cost of building new power plants. Statewide bills and regulations may appropriate funds applicable to the City of Snohomish's decarbonization work, and may inspire collaboration between the City and public utilities to meet the State's goals.

The recent Washington State House Bill 1181 (HB 1181) declares that cities of at least 6,000 in population – in counties west of the Cascades with at least 130,000 in population – must respond to climate change in their comprehensive plan by preparing a GHG reductions subelement. This declaration would therefore apply to the City of Snohomish.

SB 5126 aims to reduce carbon emissions from various sectors, particularly in communities that face disproportionate impacts from GHG emissions. The bill also introduces a cap and invest program, a Climate Investment Account, and a Carbon Emissions Reduction Account. Please see Table 5.1 for more information on these accounts and their availability to the City of Snohomish.

Senate Bill 5116 (SB 5116) requires that electric utilities transition from coal-fired electricity to carbon free electricity generation by 2045, with an emphasis on utilities that serve over 25,000 people. SB5116 complements House Bill 2311 (HB 2311). HB2311 establishes goals for the state and state agencies to reduce GHG emissions ultimately achieving net zero GHG emissions by 2050. As the electric utilities that serve Snohomish prepare for energy source transitions, there is potential for collaboration with the City of Snohomish as well as partnerships between the City of Snohomish and surrounding communities all served by the public utilities.

Greenhouse gas emissions are also a concern at the regional and county level. Policies at these levels can help guide the City of Snohomish on how to successfully reduce its own greenhouse gas emissions. PSRC recommends reducing emissions of GHG to 50% below 1990 levels by 2030 and 80% below 1990 levels by 2050. A key component of their strategy is the Regional Transportation Plan which includes a Four-Part Greenhouse Gas Strategy that includes programs and investments to advance regional implementation to support achievement of meaningful emission reductions across four elements: land use, user fees, transportation choices, and technology. The Snohomish County Sustainability Operations Action Plan[15] (hereafter referred to as the SOAP) prioritizes reducing the County's transportation-caused greenhouse gas emissions, incorporating energy efficiency, and using renewable energy technology. The PSCAA focuses on educating the public about reducing outdoor burning and wood heating to reduce carbon emissions. These governmental operations provide a comprehensive approach to reduce GHG emissions.

Buildings & Energy

Several agencies provide policies for transitioning to cleaner energy sources and strengthening building infrastructure as a way to reduce emissions and foster healthier communities. In particular, the PSRC and the HMP recommend energy conservation, energy management, and the development of alternative energy sources. The building sector (one of the largest sources of GHG emissions within the City) can implement these recommendations by retrofitting existing buildings and green building practices (per policies from the PSRC, the HMP, and the SOAP). These plans may be financially supported by SB 5126,

[15] The Snohomish County Sustainability Operations Action Plan only applies to Snohomish County government operations. While the plan does not directly apply to the City, it serves as an example if the City is interested in implementing their own sustainability operations action plan.

which creates the Climate Commitment Account to invest in the electrification of new residential and commercial buildings. Snohomish can reduce energy consumption, GHGs emissions, and prevent the need to build new power plants through these recommendations. This supports SB 5116 which requires utilities that serve more than 25,000 customers to develop resource plans to transition to 100% renewable energy by 2045.

Additionally, focusing on buildings will help the City become more resilient to climate change, namely climate disasters. The PSRC recommends that new buildings (including public services, facilities, and infrastructure) consider climate change implications when siting. The PSRC and the HMP, recommend preparing buildings for disasters that may occur, such as flooding and landslides, as well as recovery plans.

Ecosystems

Ecological protection is a core component of the SOAP, the Shoreline Management Act (SMA), and the County Comprehensive Plan. As the City contemplates its urban tree canopy program among other programs related to natural habitat, it should consider the County Comprehensive Plan's goal of no net loss of ecological function of the natural environment in Snohomish County through county-wide efforts to coordinate programs for environmental protection and restoration. The Comprehensive Plan notes that non-regulatory programs such as incentives and restoration plans can improve and protect ecological functions. Additionally, the City can partner with citizens through educational programs to achieve ecosystem restoration and protection goals. Examples noted in the Comprehensive Plan include educating landowners about protecting critical areas, engaging the community about best practices for environmental management (such as wetlands, stormwater management, and stream habitats), and encouraging volunteer opportunities for environmental restoration. The City should also note that the County Comprehensive Plan supports regulations for natural environment protection, fish and wildlife conservation areas, critical aquifer recharge areas, and shoreline protection.

PSRC recommends protecting and restoring natural systems, conserving habitat, improving water quality, and reducing air pollutants. PSRC and the HMP recommend increasing resilience by identifying and addressing the impacts of climate change and natural hazards (such as landslides, flooding, and fires) on water, land, infrastructure, health, and the economy. Such resilience can stabilize slopes and increase ecosystem resilience. PSRC recommends protecting and restoring natural resources that sequester and store carbon, such as forests, farmland, wetlands, estuaries, and urban tree canopy. Both PSRC's Vision 2050 and the HMP can be paired with the Climate Investment Account, which SB 5126 created. A quarter of funds from this account will be used to create the Natural Climate Solutions Account, which invests in projects that increase the resilience of the state's waters, forests and ecosystems.

Health & Well-Being

Several state and regional regulations and policies aim to reduce natural hazards impacts on public health, mitigate disproportionate emissions on overburdened communities, and improve air quality. SB 5126 devotes 35-40% of funds from the Climate Investment and Carbon Emissions Reductions Accounts to reduce environmental burdens and provide benefits to vulnerable communities. The Air Quality and

Health Disparities Improvement Account works to improve health disparities and improve air quality. SB 5116 mandates utilities make funding for energy assistance available to low-income households and funding for the Department of Health to study communities highly impacted by fossil fuel pollution and climate change.[16] This report's *Section 2.2 Vulnerable Groups & Environmental Justice* found that 7.1% of Snohomish County is below the poverty level, and therefore may qualify for these funds. This funding availability presents a unique opportunity for the City of Snohomish to partner with utilities and low-income residents to reduce residential energy consumption and retrofit homes to better withstand climate change-related hazards.

PSCAA focuses on public education on the dangers of smoke from wood burning and promoting cleaner energy and transportation options to protect public health from dangerous air quality. PSRC, the County Comprehensive Plan, and the HMP, all recommend increasing resilience by identifying and addressing the impacts of climate change and natural hazards on public health.

Transportation (Roads, Bridges, Multimodal)

Transportation infrastructure is an access issue the City must prioritize. The HMP includes strategies to protect transportation infrastructure, such as retrofitting bridges, stabilizing slopes, reducing flood impacts, and educating the public on emergency transportation routes. The City may contemplate these resilience and adaptation policies should the Snohomish River or Pilchuck River flood and restrict access.

PSRC cites policies to advance the resilience of the transportation systems by incorporating redundancies, preparing for disasters and other impacts, and coordinated planning for system recovery. While the PSRC's Regional Transportation Plan does briefly mention climate hazards in regard to transportation resiliency, the City of Snohomish may consider advocating that the PSRC specifically address infrastructure improvements - such as that which the City acknowledges in its HMP - in future iterations of the RTP.

Transportation is also important to the City if the City would like to reduce its greenhouse gas emissions. There are several documents at the state, regional, and county level that may support the City's efforts to do so. HB 1181 encourages the development of efficient multimodal transportation systems to reduce GHG emissions and per capita vehicle miles traveled. The PSCAA promotes technologies and best practices to reduce transportation emissions and has a program with a specific focus on access to electric vehicles for low-income residents. PSRC's Vision 2050 and its Regional Transportation Plan recommend supporting the transition to a cleaner transportation system through investments in zero emission vehicles, low-carbon fuels, and other clean energy options; and providing infrastructure sufficient to support widespread electrification of the transportation system. The Department of Ecology adopted legislation (Chapter 173-423 WAC "Clean Vehicles Program" and Chapter 173-400 WAC "General Regulations for Air Pollution Sources") that supports this goal, committing to 100% of car sales being zero-emission vehicles by model year 2035. The County Comprehensive Plan mandates air pollution emission reductions associated with land uses and transportation in order to improve public health.

[16] More information on the account is available here: https://app.leg.wa.gov/rcw/default.aspx?cite=19.405.120. Washington State's Department of Commerce's 2023 report on Low-Income Energy Assistance funds is available here: https://deptofcommerce.app.box.com/s/26hp72scwawh5qb0pml3vqph922tfby6/file/1159460337791.

Washington's SB 5126 established a Carbon Emissions Reduction Account to reduce emissions in the transportation sector. The City could tap into the above resources for ideas, potential collaborations, and funding mechanisms to reduce its carbon emissions from transportation. While expanding electric vehicle charging infrastructure is a heavy lift requiring close cooperation with the local PUD, the City could immediately make improvements to multimodal infrastructure, providing more sidewalks and bike lanes, especially in areas with new or increasingly dense development.

Water Resources

The Natural Climate Solutions Account, which Washington State created under SB 5126, invests in natural projects that increase the resilience of the state's waters, forests and ecosystems, including clean water investments, reducing flood risk and restoring the natural floodplain ecological function, and incorporating green stormwater infrastructure. The HMP includes initiatives to protect water infrastructure, such as adding redundancy to build resilience. The County Comprehensive Plan works to protect and restore the ecological function of natural watershed processes, shorelines, and water resources through supporting existing and new programs.

In compliance with the Growth Management Act requirements, the Plan works to designate and protect critical aquifer recharge, and wetland and floodplain areas. The Plan aims to protect shorelines in accordance with the SMA and to comply with the County's Phase I Municipal Stormwater Permit issued by the WA Department of Ecology. Similarly, the SMA mandates a master plan to regulate the uses of shorelines. The City's Shoreline Master Plan should include adaptation strategies to address climate change impacts, which aligns with recommendations from the PSRC.

Cultural Resources & Practices

The Cultural Resources & Practices sector stresses the importance of recognizing culturally significant ceremonies and species, and understanding the ways in which these practices relate to the City's climate goals. This includes recognizing the importance of ceremonial burning to Indigenous and other cultural groups (PSCAA)[17] and including slope stabilization goals to improve salmon habitat (the HMP).

Economic Development

Natural hazards threaten economic systems and climate technology can foster economic growth. PSRC Vision 2050 and the HMP recommend protecting businesses and implementing effective zoning practices to mitigate impacts from natural hazards. The County Comprehensive Plan stresses the need to balance environmental protection with economic development, housing needs, and property rights. The SOAP has a goal to "implement green purchasing practices," which will both make County operations more sustainable as well as grow the green economy throughout the County. The City could adopt similar policies to promote resilient, sustainable economic growth.

Other Sectors

As the other sectors are important to note, we have summarized the key take-aways. Policies within the plans we reviewed relate to the Agriculture & Food sector through promoting resilient lifeline systems

[17] Native American ceremonial burning, outside of tribal lands, requires a permit from the local fire district.

through protecting small businesses and their land use decisions. The Waste Management sector contains countywide goals to address wastewater infrastructure damage due to flooding and other disasters. The Zoning and Development sector contains policies that recommend accommodating concentrated growth in urban areas near transit hubs (PSRC) in order to grow in a way that protects the natural environment (County Comprehensive Plan, hereafter the County Comprehensive Plan). In the areas already containing growth, the County recommends improving vulnerable areas and developing maps to restrict further development in flood prone areas (HMP).

Key Takeaways & Recommendations

Common themes across the reviewed policies and plans include supporting vulnerable communities, protecting and enhancing ecosystems, transitioning to a clean energy economy, and building resilience across infrastructure. The regulatory framework reveals how the state, regional, and county goals support the City's role in climate action. Cross Jurisdictional / Regional Collaborations goals include improving regional collaboration across jurisdictions, including with Tribal Nations, agencies, and non-governmental organizations, to advance resilience, adaptation, and mitigation actions (PSRC, the Snohomish County HMP, and the County Comprehensive Plan). The City should look to higher levels of government for technical and financial support (such as the Climate Commitment Account and the Natural Climate Solutions Account) and cross-jurisdictional collaboration. Identifying synergies, utilizing regional resources, and accessing financial and technical support will maximize the City's effectiveness and reduce its costs in building climate resilience across all sectors.

Section 6: Environmental Protection Element Gap Analysis

The Environmental Protection Element of Snohomish's Comprehensive Plan is a brief but important section in the plan's narrative, laying out goals and policies to protect natural assets, preserve environmental health, and further relevant policy. At nine pages long, the element presents a high-level overview of Snohomish's efforts, avoiding detailed descriptions or analysis of existing policy. This is largely by design; comprehensive plans are not intended to be detailed policy documents, but rather present a broad vision of a city's intentions and values with regard to planning. Seeking to understand how well the Comprehensive Plan communicates Snohomish's intentions with regard to climate mitigation and adaptation, we conducted a gap analysis of the Environmental Protection Element as well as the other sections of the Comprehensive Plan. The analysis identifies individual sections that conflict with Snohomish's efforts in GHG mitigation and climate adaptation, highlighting existing gaps that can be addressed during the 2024 plan update.

Guiding Criteria

In order to construct a useful gap analysis of a comprehensive plan it is important to understand what an ideal plan looks like. In order to do this we used the Washington State Department of Commerce Model Climate Elements guidance to construct a list of desired criteria for an effective climate element. The criteria selected were chosen by independent analysis of Commerce guidance and are as follows:

- Plan has a clear vision statement and purpose
- Plans policies are supported by engagement with frontline communities
- Plan covers all potential hazards
- Plan clearly prioritizes risks to assets
- Plan has both adaptation and mitigation elements
- Plan is achievable
- Plan consists of strategies and policies that are well integrated with other areas
- Strategies and goals are supportive
- Goal or strategy is sufficient in addressing hazards

After our initial reading of the Environmental Protection Element we found that its length and level of detail meant that direct analysis of what was written would be insufficient to illustrate gaps or weaknesses. Additionally, the Environmental Protection Element was included voluntarily by the City of Snohomish and is not a required element of the statewide Growth Management Act or GMA. As a result, the guidance for plan objectives and items to be included is not as readily available as the GMA mandated categories such as the Transportation or Shoreline elements. By using the Department of Commerce framework discussed above, we were able to better consider what was missing, what the Environmental Protection Element could be, and the broader processes represented within the Element. We chose to apply this analytical framework qualitatively, as each component varies to such an extent and scale that a quantitative method would not be applicable for each criteria. For instance, whether the "plan is achievable" is a much broader question than whether the plan has a "clear vision statement", which can be answered by reviewing the Plan's introduction. Due to time constraints and the greater amount of information offered by the rest of the plan, we elected to take a more general approach to reviewing the other sections, evenly dividing the Comprehensive Plan into three parts and each choosing one to closely read. The sections contain the following:

- Section 1: Introduction, Land Use, Housing
- Section 2: Economic Development, Environmental Protection, Shoreline, Parks
- Section 3: Transportation, Capital Facilities, Utilities

Through our analysis we were able to identify how the plan's other components related to the goals and strategies laid out in the Environmental Protection Element and identify opportunities to address climate mitigation and adaptation in future plans. The following gap analysis identifies opportunities for improvement within the Environmental Protection Element and throughout the Comprehensive Plan, laying the groundwork for Section 7, which provides a menu of policy options to support mitigation and adaptation in Snohomish.

Environmental Protection Element Gaps

Plan has a clear vision statement and purpose.

- The element does not fully support its broad mission statement
- Policy framework is broad but there are not enough goals and policies to support its stated purpose

The Element states that its "purpose in this Comprehensive Plan is to provide a policy guide for minimizing the effects of natural hazards, protecting regulated critical areas, and generally encouraging a sustainable approach to community development." This mission statement is not supported by the policies and does not adequately minimize natural hazards nor do they fully address the "sustainable approach to community development."

Examples of shortcomings:

- Lack of mention of Climate Change: though the mission statement of the Element is highly impacted by the impacts being caused by climate change, there is no mention of climate change nor the impacts that are sure to worsen as a result of it in the goal or strategies. Mention of climate change and inclusion into strategies could strengthen the effectiveness of the stratigies. Places where mention would increase effectiveness:
    - E.P. 2.1 Hazard mapping- inclusion of intensification of hazards as a result of climate change is a critical step to ensuring sustainability and this policy would be more effective if climate was added into the hazards.
- Effective community development requires consideration of public health as a result of environmental protection.

  - In order to meet the goal of “encouraging a sustainable approach to community development” there should be some inclusion of strategies or language that prioritize the impacts environmental protection can have on public health.

Plan’s policies are supported by engagement with frontline communities.

- There is a lack of goals, policies, and strategies aimed at engaging communities and protecting frontline communities

Due to our limited scope the level of community engagement strategies is unknown but the plan would benefit from including language that makes the engagement process more clear. There is limited language regarding the importance of equity across the entirety of the comprehensive plan. But this does bring up the concern that engagement efforts are not mentioned exclusively in the Element but could potentially improve the plan. The plan makes mention of indigenous communities but does not include the reliance that the Tulalip and other tribes have historically had and continue to have to this day.

Frontline communities could be directly mentioned in strategic and goal language as an equitable approach to comprehensive planning - this is critical to the plan's success.

Examples of shortcomings:

- Level of inclusion of equity concerns: there is a lack of emphasis on equity in the Environmental Protection element and the way in which vulnerable communities are particularly at risk of environmental degradation. Where to mention equity:
  - Goal EP 2 - This goal includes strategies that help to identify where hazards may occur but it is missing an element of vulnerability. The inclusion of Some vulnerability analysis would strengthen the element's effort towards creating a guide to sustainable community development.

Plan covers all potential hazards.

- Wildfire smoke not clearly addressed
- Element is very focused on flooding to the detriment of other hazards
- No mention of increased severe heat days

The element focuses mainly on flooding and erosion to environmental resources but it does not mention other hazards that will have increasingly substantial impacts on the environment and the community more broadly in the future such as increased heat days and wildfire smoke. The UW class Risk Assessment placed wildfire smoke and heat hazards as being potentially the most impactful hazards.

Examples of shortcomings:

- No mention of Wildfire smoke: wildfire smoke is a critical threat to the environment and public health of Snohomish and it is critical to mention its impacts on environmental assets. Where it could be included:
  - EP Goal 4: Air quality– This is a perfect goal to include strategies related to wildfire smoke as smoke has a direct impact on the quality of the air. Impacts from smoke could affect many of the strategies mentioned under this goal such as with EP 4.2.

- No mention of severe heat days: severe heat days are another threat that will likely have considerable impacts on environmental assets and public health.
  - Goal 2 – This goal would be better supported by including language regarding heat and heat mapping.

Plan clearly prioritizes risks to assets.

- Plan does not asses hazard likelihood in preparing adaptation strategies

The main shortcomings when talking about risks to assets is that the element does not discuss how likely different risks are to affect the environment. The element also doesn't mention how climate change might mess with the assessment of risk. Though there is a county wide Hazard mitigation plan that is in effect in the City, some understanding of how these hazards that are a risk to the City more broadly could directly affect the environmental assets. We identified several potential ways to address this gap:

- Climate change needs to be mentioned: though the plan does include hazard mapping as a strategy as well as pursuing the use of the best available science more strategizing needs to be done in regards to determining increased risk due to climate change.
- EP 1.1 Best Available Science– In order for this strategy to be effective over the course of the new comprehensive plan it needs to incorporate climate change science. This needs to be an explicit priority in order to provide effective protection.
- Hazard indexing/rating: an important part of protecting the environment is understanding what is threatening it and in order to do this risks must be assessed and rated to inform effective policy. These ratings would preferentially be done with robust community feedback.
- EP 1.2 Technical guidance– THis strategy is incomplete and would benefit from incorporating some notion of risk assessment through professional and community mechanisms.

Plan has both adaptation and GHG mitigation elements.

- Element mostly focused on adaptation
- Strategies, goals, and policies for GHG mitigation are lacking or incomplete

The majority of the goals and policies are targeted at adaptation strategies often referred to as mitigation in reference to hazard mitigation. The Element includes very little in the way of GHG mitigation from non-transportation sources. While the plan mentioned prioritizing mitigation, it could be included into a number of other strategies to increase the plan's effectiveness. If the City wishes to pursue protecting the environment, they must include ample avenues for both mitigation and adaptation elements. Gaps and potential ways to address them include:

- EP 1.7 Innovative Designs – This could be a good place for the inclusion of a green building initiative.
- EP Goal 4 – The main polluter in the city is residential use of electricity and an inclusion of a strategy to help mitigate this specific source would be beneficial in helping to achieve the goal.

Plan is achievable.

- Previously mentioned gaps make stated goals difficult to achieve
- Some of the strategies are far too broad to be effective

Though the strategies mentioned are achievable, the aforementioned gaps make it difficult to achieve the plans stated goals. The main gap present is a lack of supporting text for identified policies. While part of this is caused by Comprehensive Plan structure, planners could strengthen the document by clearly describing strategies and creating a clearer picture of their intended applications.

Plan consists of strategies and policies that are well integrated with other areas.

- The element's subject matter overlaps considerably with other elements and explicit mention of this would benefit the plan creating a more integrated document

The broad scope of this element creates an environment in which multiple elements overlap with its subject area– specifically the Shoreline, Parks, and Transportation elements. Inclusion or reference of considerations from other elements with these elements would help to more fully address the mission of the Environment Protection Element and likely strengthen the approach of the City to address the issue of environmental protection.

Strategies and goals are supportive and not adversarial.

- No noticeable gaps

Goal or strategy is sufficient in addressing hazards

- Goal 4 regarding air quality is incomplete and does not address all factors in air quality (wildfire, not transportation pollution)
- Goal 4's policies to deal with air quality are insufficient
- No mention of worsened heat

One of the main gaps noted was the plan's lack of GHG mitigation measures and this can be represented in goal 4's policies that don't completely address emissions enough to make a significant impact in GHG reductions.

Broader Plan Considerations

The broader plan elements—those not focused on environmental protection—are quite comprehensive. While there are policies that completely omit any reference to Environmental Protection, generally they are notable not so much for omission, but for the use of suggestive, less compelling, and less directive language. Using words such as "encourage" and "promote" makes measuring progress difficult. To strengthen these elements, and the overall plan, stronger and more action-oriented language could be used.

Land Use Element

The Land Use element of the plan, as a required element of Washington's GMA, has goals and policies that significantly overlap and refer to the other elements of the plan. Many of these policies acknowledge environmental protection, but could benefit from strengthened, directive language and measurable progress targets. A significant portion of the Land Use policies directly correspond with Housing element policies, and examples of these can be found under the Housing element. Other Land Use policies forego any mention of environmental protection. The following Land Use policy and its sub-policies concern industrialization. There is an opportunity here to incorporate environmental protection into the policies and goals.

- *LU 7: Designate sufficient industrial areas of varying sizes and types to encourage the development of the city as a small diversified manufacturing and technology center and to provide locations for other land uses that require separation from residential and other uses.*

Several policies indirectly encourage behavior counter to a sound environmental protection policy, such as supporting expansion into areas without a strong environmentally focused plan for annexation. Annexation and growth is inevitable, and this is an opportunity to incorporate environmental protection more strongly into growth areas.

- *LU 11. Approve annexations that support logical expansions of the City boundaries, conserve City resources, and result in no substantial reductions in levels of service provision to the existing community.*

The Land Use element is an opportunity area for policy recommendations that would not only strengthen the language used but more closely align Land Use element policies with goals outlined in an expanded Environmental Protection element.

Housing Element

The Housing element, also required by the GMA, again indirectly addresses many components of housing that can be used to lessen climate impacts. It does not identify any goals or provide any focus on policies or strategies that would directly address lessening climate impacts through housing policies. There are policies supporting and encouraging multifamily housing, as well as references to encouraging and increasing "missing middle" housing, but neither are described as such to indicate that either are priorities. Several examples are below.

- *LU 2.3 Residential densities. Evaluate options for increasing district-wide residential densities where it will not have a detrimental effect on infrastructure and existing neighborhoods and where adequate accommodations are made for public spaces and pedestrian facilities.*

- *LU 2.16: Missing Middle Housing. The City should consider a new type of single-family zoning designation that allows for the development of duplexes, triplexes, and fourplexes, without density constraints.*

The language used is not directive and lacks any incentives for follow-through. The language could be improved with actionable items and target goals to more effectively increase the available housing stock. This also is an opportunity area for recommendations that would align Housing policies with the Environmental Protection element, as well as an opportunity to strengthen the existing language use. As with the Land Use element, frontline and vulnerable communities are also under-represented in this element, and provide another opportunity to make the Housing element more robust.

Economic Development Element

The Economic Development element indirectly addresses environmental concerns when referencing positive outcomes of strong economic development objectives such as a high quality of life. However, the Economic Development element does not contain policies that directly address environmental protection. This is an opportunity area for policy recommendations especially as many economic drivers, such as tourism, have the potential to be highly impacted by the results of climate change. Goals and strategies could also focus on encouraging more environmentally friendly industries to locate in Snohomish.

Shoreline Element

The Shoreline element is longer and more thorough than the Environmental Protection element and does a better job addressing the interrelation between its element and other elements. The plan overlaps especially with the Environmental Protection element. This overlap means that the two elements might reference each other and contain complementary goals, policies and strategies in order to more efficiently reach their goals. That being said, the Environmental Protection element has little reference to the Shoreline element in its language. In order to bolster the effectiveness of the element, the inclusion of the element's similarities in the text might enhance the comprehensiveness of the plan. The Shoreline element falls short much like the rest of the plan in regards to consideration of frontline communities and especially with no mention of Indigenous tribes tied to the Snohomish River.

The inclusion of this Shoreline Protection element would suggest that the Environmental Protection element could focus more on other elements that are sure to affect the City such as wildfires or increased heat concerns. The element also provides a nice framework for expanding the Environmental Protection element with adjacent industries and concerns listed under each goal in order to get a clearer vision of what the goals will look like in implementation.

Parks Element

This is another GMA-required element and resembles the Shoreline element. The Element also overlaps with the Environmental Protection element significantly and its goals could be better referenced by the Environmental Protection element in order to strengthen its efforts.

The Parks section could include climate adaptation considerations not addressed in the Environmental Protection element such as cooling facilities in parks to deal with more extreme heat days or even the inclusion of stormwater parks or similar facilities in order to deal with the flooding hazards.

- *PRO 2* is centered around the preservation of “open space” and “ecologically significant” and “sensitive” spaces which has a large implication on the protection of the environment. The element also prioritizes the acquisition of vulnerable shorelines in an effort to better preserve them.

Transportation

The transportation element largely describes activities necessary to fulfill state planning requirements, such as Level of Service and Concurrency provisions. Beyond these mandated aspects, however, the Element also illustrates the City’s vision for the future transportation network, a vision that sometimes finds itself in conflict with Snohomish’s stated goals on climate mitigation. There are several specific policies that conflict with mitigation efforts:

TR 2: SR 9 capacity. Support efforts to increase capacity on State Route 9

> Increasing capacity on SR9 would induce increased demand, resulting in greater levels of GHG emissions from car travel. If the improvements to SR9 are part of a regional effort that is not under the City’s control, that should be stated to communicate consistency of goals and objectives to the reader. If the project is exclusively under the City’s control and is not part of a mandated Level of Service or Concurrency improvement, then efforts to increase capacity run directly counter to the City’s stated climate goals and its requirement to reduce emissions per Washington State emissions reductions goals.

TR 14: Complete streets. Incorporate pedestrian, bicycle, and transit-friendly designs into roadway improvement projects where feasible.

> Complete streets projects are absolutely in line with Snohomish’s climate goals, however, the Plan would benefit from stronger language here. Using “where feasible” gives the reader the impression that Complete Streets are not necessarily a priority, which is not what the city is trying to communicate. While this is specifically a matter of semantics, the Comprehensive Plan

communicates Snohomish's planning intentions and could be revised to better reflect planning goals. One way to accomplish this would be to identify a class of streets, such as connecting streets between arterials and neighborhoods, that the City intends to prioritize for complete streets improvements. Another option could be to describe types of complete streets improvements that would be a good fit for Snohomish's small city character; while bus lanes may not be a good fit for the historic downtown, widening sidewalks to create more pedestrian space would certainly work.

TR 29: Electric vehicles. Evaluate opportunities to install charging stations for electric vehicles.

Considering Snohomish's relatively remote location and lack of rail travel options, it is likely that personal vehicles will remain the dominant choice for commuting and other travel going forward. Snohomish has noted concerns about lacking the capacity for mass electrification, however, that should not discourage proper planning for increased EV consumer demand. One way to address this would be to include a provision to analyze the amount of public EV charging the city currently has capacity for, and whether capacity could be expanded in the near term, laying out different capacity scenarios and the amount of public charging each could support. This policy could also be a good place to describe plans or intentions for coordination with the Snohomish County PUD on electric vehicle infrastructure.

Capital Facilities

The Capital Facilities element presents Snohomish's goals and policies for its infrastructure, both existing and planned. The Element is unique in that it also includes detailed financial information and tables of funding schedules for various capital projects. While some Comprehensive Plans do not update Capital elements regularly, Snohomish notes that theirs is "regularly calibrated" and is revisited on an annual basis; this allows us to assess it as an up to date view of Snohomish's current and planned infrastructure.

- *CF 1.2: Capital improvement criteria. Proposed capital improvement projects shall be evaluated and prioritized using all the following criteria: a. Whether the project supports land use plans and is consistent with capital priorities established in transportation, utility, and park plans; b. Whether the project is needed to correct existing deficiencies, to maintain or replace facilities, or to provide capacity for future growth; c. Whether the project will eliminate a public hazard; d. Whether the project is consistent with prudent fiscal management, including but not limited to costs associated with future maintenance and operations, based on an evaluation of alternatives; e. Whether the improvement will encourage economic development in targeted areas; and f. How the project may affect natural and cultural resources.*

The Capital Facilities Element includes the above provision that projects should be evaluated on several criteria to ensure suitability and financial sustainability. The list of criteria, while thorough, does not include climate concerns, both in terms of mitigation and adaptation, which should be added to reflect city, county, and state commitments. This would not be a significant departure; criteria a. and d. concern the long-term feasibility and compatibility of projects, and criteria c. and f. concern the natural environment's relationship with the project. Climate risks such as flooding (whether from rivers or heavy rainfall), extreme temperatures, and drought all have the potential to damage or limit the utility of infrastructure projects and should be considered. For example, a project that adds significant amounts of impervious surfaces without mitigation for rainwater would be a greater problem in the future than it would be currently. In terms of mitigation, capital project compatibility with Snohomish's climate goals should be considered, especially for transportation projects that have the potential to induce additional vehicle trips. One way to include these concerns would be to add additional criteria on project compatibility with climate mitigation and add language about projects increasing hazard risk to criteria c.

Utilities

The Utilities Element discusses the planning and maintenance of electrical, natural gas, waste, wireless internet, and communications infrastructure. All utilities under direct city control are discussed in the Capital Facilities Element. Snohomish receives power from the Snohomish County PUD, natural gas from Puget Sound Energy, contracts waste collection to Republic Services/Allied Waste, and is served by a variety of communications (internet, cable, phone) providers.

- *UT 1.16: Alternative technologies. Encourage the conversion to cost-effective and environmentally sensitive alternative technologies and energy sources.*

The Utilities Element, largely due to its specificity, technical nature, and reliance on outside providers, has very few actionable gaps. The one note we made is that UT 1.16 would benefit from stronger, more specific language. This is a minor note, as the electrical grid is outside of Snohomish's control, but word choices such as "encourage" and "environmentally sensitive" do not communicate the high priority Snohomish places on sustainability and climate mitigation. This policy presents an opportunity to discuss paths to electrification of vehicles, vehicle charging infrastructure, and home appliances, each of which will play key roles in Snohomish's path towards a low carbon future.

Conclusion

Comprehensive plans serve the particular purpose of guiding government actions on multiple fronts. Much of their strength is derived from the breadth and ability to be applied to differentiated situations; however, if plans become too broad or omit certain concerns they become an inaccurate or incomplete guide for stakeholders. The Environmental Protection element is an elective element of the comprehensive plan and is necessary and important to secure Snohomish's future amid a changing climate. We identified the above criteria based on guidance from the Washington Department of Commerce but the overall thematic pattern is that the gaps we have identified are areas that are overlooked or not adequately addressed in the plan. These gaps were mainly found in the Environmental Protection element but we were able to analyze other sections to find significant gaps. We can generalize the identified gaps as the following:

- Policies or goals that directly conflict with mitigation planning
- Policies or goals that do not consider climate adaptation/changing risks
- Policies or goals that would benefit from more precise or stronger language

Generally speaking, the Comprehensive Plan is well thought out, and we acknowledge that the Plan is not a policy implementation document; that being said, there are certainly opportunities to more thoroughly address climate mitigation and adaptation throughout.

Section 7: Draft Goals and Policies for Climate and Environment Element

The University of Washington Climate Planning Studio previously identified increased flooding, precipitation, extreme heat events, drought, and wildfire as the climate hazards most applicable to the City of Snohomish. The Studio also identified critical assets in the City and performed a Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis to determine which assets are most vulnerable to climate change impacts.[18] Following the Department of Commerce Climate Element Planning Guidance, this section (Section 7) summarizes the background and processes used to prepare a menu of draft goals and policies that the City of Snohomish can utilize to incorporate climate change mitigation and resilience into their 2024 Comprehensive Plan Update.

Overarching Climate Goal

To reduce its climate vulnerability to the maximum extent feasible and align with state and county climate goals, the City of Snohomish must reduce its greenhouse gas (GHG) emissions by 35% in the next seven years, ultimately reaching net zero GHG emissions by 2050. Under a net zero emissions condition, the City would balance any GHGs emitting to the atmosphere with GHGs removed from the atmosphere, which is achieved by carbon sequestration. For the City to reach this goal, Snohomish would need to reduce its emissions by approximately 28,000 metric tons (MT) of carbon dioxide equivalent (CO2e). This overarching emissions reduction goal is based on a greenhouse gas inventory conducted for the City as part of this studio and is the foundation of remaining mitigation goals and policies to be incorporated into the City's Comprehensive Plan.

Policy Recommendations

As discussed under Section 5, the Washington State Legislature passed legislation in May 2023 requiring communities with populations greater than 6,000 in Growth Management Act counties – including Snohomish County – to incorporate climate change mitigation and resilience into their comprehensive plans. In anticipation of this legislation, the Washington State Department of Commerce developed guidance for cities and counties addressing both greenhouse gas reduction and climate resilience in their planning efforts. The guidance, which became available for public comment beginning in March 2023, includes 213 draft goals and policies, divided into eleven "Climate Nexus Sectors." These sectors, which are listed in Table 1, are consistent with the sectors used by the University of Washington Climate Impacts Group in projecting specific climate impacts, such as flooding or extreme heat, to communities across the state, and have been used across deliverables in this studio to evaluate the applicability of hazards, regulatory environments, and policies.

[18] Results of SWOT analysis can be found in 'Section 4' of this report

Table 7.1: Climate Nexus Sectors from Washington State Department of Commerce and UW Climate Impacts Group

1	Agriculture & Food Systems
2	Buildings & Energy
3	Cultural Resources & Practices
4	Economic Development
5	Ecosystems
6	Emergency Management
7	Health & Well-Being
8	Transportation (Roads, Bridges, Multimodal)
9	Waste Management
10	Water Resources
11	Zoning & Development

The goals and policies included in the Department of Commerce guidance document are a synthesis of policy recommendations from state and federal agencies including the Washington Department of Ecology (Ecology), Washington Department of Fish & Wildlife, the United States Environmental Protection Agency (USEPA), and the Federal Emergency Management Agency (FEMA). The guidance also includes recommendations from the University of Washington Climate Impacts Group, other universities, and the C40 Cities Climate Leadership Group. Due to time constraints and the comprehensive nature of the guidance, the Studio focused its efforts under Task 7 on identifying and prioritizing goals and policies included in the guidance. The group used a 0-4 rating system to rank goals and policies included in the Commerce guidance based on their applicability to the City of Snohomish, their feasibility given our understanding of the City's resources, their effectiveness in mitigating greenhouse gas emissions or building resilience to anticipated climate impacts, and their alignment with expressed City interests. The policy ranking methodology is detailed in the Section 7 Methods section on page 20.

After the initial policy ranking was complete, the list of goals and policies was narrowed to 188 by eliminating any items from the Department of Commerce guidance that were determined not to apply to the City of Snohomish. The 188-item, Comprehensive Policy Menu includes goals and policies as they were provided by the Department of Commerce, with a column of proposed edits. This document, included as *Appendix F: Comprehensive Policy Menu*, is provided as a reference should the City desire to review the source language behind our policy recommendations.

The Comprehensive Policy Menu was then sorted into goals, compared to the state and county-level regulations and policies discussed in Section 5, and revised to eliminate redundancies and improve relevance to the City of Snohomish. The results of the gap analysis discussed in Section 6 were also reviewed to determine if the provided policies meet an identified gap in the City's Comprehensive Plan or are consistent with an existing policy. The resulting Tailored Policy Menu includes 31 goals with 139 supporting policies across 10 Climate Nexus Sectors. It is important to note that goals and policies that the Department of Commerce included under "Agriculture" were redistributed because the agricultural sector within the jurisdictional boundary of the City of Snohomish is limited. The Tailored Policy Menu document (*Appendix G*) includes estimates of the expected impact of each goal/policy– the extent to which implementation of the goal or policy will mitigate greenhouse gas emissions or build resilience to a specific climate hazard– the estimated cost of implementing each goal/policy, the anticipated timeline for implementation, and considerations regarding the feasibility of implementing the goal/policy within Snohomish. These descriptors are intended to assist City staff and other stakeholders in deciding which policies to include in the 2024 Comprehensive Plan Update.

Key Takeaways

A significant portion of policies in the Tailored Policy Menu (42 of 139) are related to the Transportation and Zoning & Development Climate Nexus Sectors. Land use decisions, including sustainable site and building design standards and climate-informed siting of public facilities, coupled with an increase in multimodal transportation options within the City, will be critical in creating a path towards meeting the City's overarching emissions target and building a more resilient Snohomish. There are 34 policies directly related to ecosystems and water resources that highlight the importance of protecting and enhancing the natural environment. Ecosystems are especially vulnerable to the identified climate change impacts that will affect Snohomish, and long-term ecosystem function is fundamental to overall climate resilience.

Equity is identified as a co-benefit ("promotes equity and justice") but specific language to equity and justice can be better integrated into the policy language provided by the Department of Commerce. For example, in the Ecosystems sector, we added two policies borrowed from the *King County 30-Year Forest Plan* to fill a gap in the relationship between tree canopy and equitable community involvement. A further limitation in our analysis of equity in the policies is the absence of the planned "Climate Equity and Uplift Community Leaders" content in the Appendix to the Guidance. The City should review this document when it becomes available to ensure that equity considerations are incorporated throughout the 2024 Comprehensive Plan update, particularly as it relates to climate planning.

Using the recommendations in *Appendix G: Tailored Policy Menu*, we hope the City of Snohomish will be able to integrate a wide range of policy options that meet climate goals and are responsive to the needs and limited resources of a small community.

Section 8: Carbon Sinks Identification & Storage Inventory

The natural environment sequesters and stores carbon and carbon dioxide (CO_2) as part of the ongoing carbon cycle[19]. Different types of land cover sequester carbon at different rates, with some being dramatically more efficient "carbon sinks" than others. Carbon sinks are important because of their ability to remove CO_2 from the atmosphere, converting it into solid matter (terrestrial environments), storing it in sediment (lakes, wetlands) or storing it within water itself (lakes, oceans). For cities looking to mitigate their climate impact, protecting or expanding natural carbon sinks offers many advantages, from their proven effectiveness in removing CO_2, to co-benefits, such as increased green space, flood attenuation, wildlife habitat, and improved air and water quality.

In our assessment of carbon sinks within the City of Snohomish's Urban Growth Boundary (UGA), we provide a high level overview of total carbon sequestration per acre for six types of natural land cover found within the city, referencing existing literature on carbon sequestration to present a clearer picture of the City's carbon sink assets. It is important to note that several of the studies consulted were conducted outside of Washington State, and our results should not be taken as exact measurements of the City's carbon stocks. Our results do, however, give a good indication of the most important areas and land cover types for carbon storage and potential for climate change mitigation. The City can use these findings to more effectively craft relevant climate change mitigation and adaptation strategies.

Background: Carbon Sequestration for Relevant Land Cover Types

Trees are the most well known natural carbon sink, taking in CO_2 from the air via respiration and releasing O2 into the atmosphere, sequestering carbon within the structure of the tree itself. Trees will continue to sequester carbon until they die, at which point the carbon will remain inert until decomposition or fire releases it into the atmosphere. The age and species of a tree have significant implications for sequestration potential.

Carbon is present in lakes as both dissolved carbon and mineralized carbon in sediment. Carbon enters lakes via water inflows as dissolved carbon, or as atmospheric carbon entering the water system directly from the air. Over time carbon is buried in sediment, trapping it below the surface. It is important to note that lakes, particularly eutrophic[20] lakes, can also be *sources* of carbon. When algae and other lifeforms engage in primary production (the production of energy from chemical compounds) they take in CO_2, however when the algae later decomposes CH_4 (methane) is produced. Because of the dual potential of lakes, it is important to take into account its specific characteristics when assessing carbon sequestration potential.

---

[19] Carbon cycles through the atmosphere, terrestrial ecosystem, and water systems. Through photosynthesis, trees and other plant life consume CO_2 and release Oxygen (O_2), storing CO_2 within their branches, trunks, and roots. When plant matter decomposes or burns, the stored carbon is then released. Water, particularly ocean water, stores dissolved CO_2. Sediments also store CO_2, especially dense or saturated sediments, because a lack of O_2 significantly reduces decomposition rates.

[20] Eutrophic refers to high levels of biological productivity, usually due to excessive nutrients like phosphorus and nitrogen from urban and agricultural activities. Eutrophic lakes generally exhibit algal blooms and have water quality issues.

Similar to lakes, wetlands store carbon in sediment, with the additional sink of wetland vegetation taking in CO_2 via respiration. Wetlands can exhibit the same sink/source dynamic as lakes, and specific attention should be paid to wetland characteristics (brackish or freshwater, vegetation type, quality and density) when evaluating sequestration. Because wetland sediment is stored closer to the surface than lake sediment, whether a wetland is disturbed or not can greatly change sequestration dynamics. If a wetland is frequently disturbed (by dredging, for example), it exhibits reduced sequestration capability. In fact, undisturbed wetlands store almost twice as much carbon as disturbed wetlands (Nahlik and Fennessy 2016).

Inventory Overview

Based on a review of the best available and peer-reviewed scientific literature, as well as consultation with experts, we identified six land cover types in Snohomish that have the most potential to store significant amounts of carbon; evergreen forest, deciduous forest, mixed forest, lake (Blackmans), wetlands, and wet grassland/shrubs/tree mix (Riverview Wildlife Refuge). We included only land cover categorized as forested (evergreen, deciduous, and mixed), according to the National Land Cover Database (NLCD) (Dewitz and USGS 2021), as well as wetlands, according to the City provided GIS wetland inventory. With this data, we created a pie chart showing the distribution of carbon storage (Figure 8.1), a table of land cover types, sequestration rates, and total carbon storage (Table 8.1). We also created two GIS maps: one showing the City's major carbon sinks by land cover type (Figure 8.2), and the other showing carbon sequestration rates in tonnes (metric tons) of carbon per acre (t C/acre) (Figure 8.3).

Based on common methods in the literature, we did not include parks, or street trees and other vegetation due to a lack of complete data and lower sequestration potential[21]. We also did not include streams or the City's portions of the Pilchuck and Snohomish Rivers because, although rivers may play an important role in transporting carbon laden sediment, they are dynamic systems with constantly fluxing carbon and are generally not considered net carbon sinks (Ford and Fox 2021).

Determining Sequestration Rates

While the literature on wetlands as carbon sinks is well developed, most local research focuses on saltwater or brackish wetland ecosystems, making it inappropriate to use in a freshwater context. After a review of relevant literature, we decided to use Tara Mazurcyzk and Robert P Brooks' 2018 paper "Carbon Storage Dynamics of Temperate Freshwater Wetlands in Pennsylvania". While the location is an obvious mismatch, the researchers study 193 sites, provide breakdowns of specific wetland types[22], and separate out different types of carbon storage within the wetland environment[23]. Because of this, we reasoned that this paper would allow better informed environmental planners to determine which

[21] Ideally, a complete and accurate accounting of the City's total carbon storage would account for these land uses because, taken together, they could provide a consequential portion of the City's total carbon storage.
[22] Lacustrine human impounded, Perennial/seasonal depression, Riverine beaver impounded, Riverine headwater complex, Riverine lower perennial, Riverine upper perennial, and Slope
[23] Above ground carbon, below ground carbon, soil carbon, coarse woody debris, shrub cover, and herbaceous cover

specific wetland conditions (microclimate, site features, carbon sinks present) best matched local conditions if they wanted to attain a more specific estimate than the one we provide here.

To assign sequestration rates (t C/acre) to vegetation land cover types (forests and the wildlife refuge), we referred to the Port of Seattle's recent Carbon Sequestration Assessment (The Watershed Company 2018), which relied on tables developed by Dushku et al (2007) that list sequestration rates for different vegetation types in Washington. We assigned rates from these tables to their corresponding NLCD forest cover and vegetation types. To corroborate the validity of these rates, we compared them to sequestration rates from other sources (The Nature Conservancy 2023 and Williams et al 2020). For a complete and detailed understanding of our methods, please refer to *Section 8 Methods* in the *Methods* section of this report.

Results

The City has about 425 acres of major carbon sinks within the UGA (Table 8.1) with an estimated carbon storage of 19,250 metric tons. Most of the City's carbon is stored in wetlands, accounting for over half of the storage acreage. At 70.6 metric tons of carbon per acre, wetlands also have the highest carbon sequestration rate, meaning wetlands account for over 68% of the City's total carbon storage (Figure 8.1). According to the City's wetlands dataset, most of the City's wetlands are either palustrine (freshwater) emergent, palustrine shrub, or palustrine forested associated with a network of small streams that eventually flow into the Snohomish River. Forested wetlands offer the greatest above ground carbon storage, while frequently flooded emergent wetlands provide greater soil carbon storage (Marzurczyk and Brooks 2018). This is because saturated, anaerobic soils have much higher organic carbon content (Mitsch et al 2013).

Table 8.1: Major carbon sinks, associated carbon sequestration rates, and total storage (t C)

City of Snohomish Major Carbon Sinks			
Carbon Sink	Total acres (within UGA)	Estimated** Sequestration Rate (t C / acre)	Estimated** Total Carbon Storage (t C)
Wetland	185.86	70.6	13130
Mixed Forest	53.69	52.1	2800
Evergreen Forest	30.02	42.9	1290
Deciduous Forest	68.67	27.4	1880
Riverview Wildlife Refuge	23.25	6.4	150
Blackmans Lake*	63 (800 acre-ft)	NA	<1
Total Acres	**424.49**	Total Storage (t C)	**19,250**

* Blackmans Lake sequestration rate was based on volume of water (800 acre-feet) (Snohomish County 2003) rather than acreage.
**These are very rough estimates based on limited available data and a literature review, are not verified by any field measurements, and are not intended to represent actual carbon storage (see *Section 8.6 Limitations* and *Section 8 Methods* for more details).

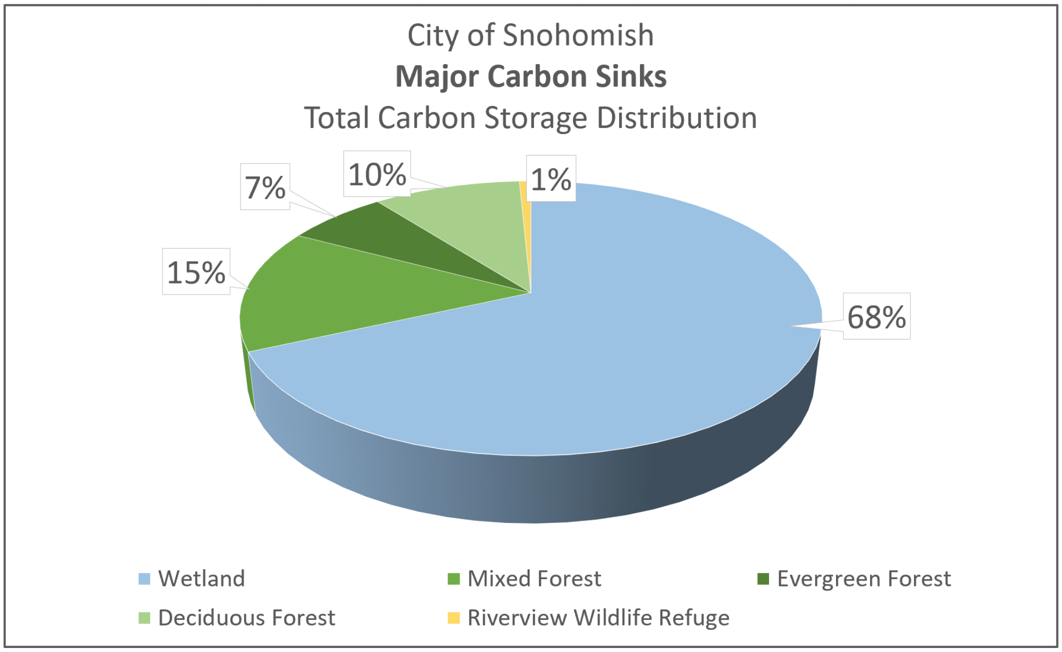


Figure 8.1: Total carbon storage distribution of major carbon sinks within the City of Snohomish UGA, based on sequestration rate (t C per acre).

The second largest carbon sink land cover class, based on total acreage and sequestration rate, is mixed forest with nearly 15% of the City's storage, followed by deciduous forest at nearly 10%, and evergreen forest at almost 7%. The Riverview Wildlife Refuge was included in our analysis because it shows up as a major sink on the Nature Conservancy's carbon sink map (The Nature Conservancy 2023), despite being incorrectly classed on the NLCD database as cultivated crops. However, according to the carbon sequestration rates obtained from the literature review, which are based on vegetation type (in this case a mix of wet grasslands and shrub/tree), the wildlife refuge makes up less than 1% of the City's carbon storage. Despite this finding, we included the refuge among the City's major carbon sinks because of its future sequestration potential, as the vegetation becomes more forested and matures. Blackmans Lake, on the other hand, had such low total carbon storage, according to our method of quantifying storage based on the available studies, that it does not show up in the pie chart (See *Section 8.6: Limitations* for details). This high-level carbon sink inventory and review of the best available science shows that wetlands have the highest potential for storing carbon in Snohomish, and therefore have the highest potential for mitigating climate change, yet are also at the greatest risk of becoming a carbon source, if not protected and adaptively managed. Additionally, among forest types, mixed forests with both deciduous and evergreen trees provide the most efficient carbon storage because evergreen forests provide the greatest storage long-term, while deciduous forests provide more immediate carbon sequestration potential (Dushku et al 2007).

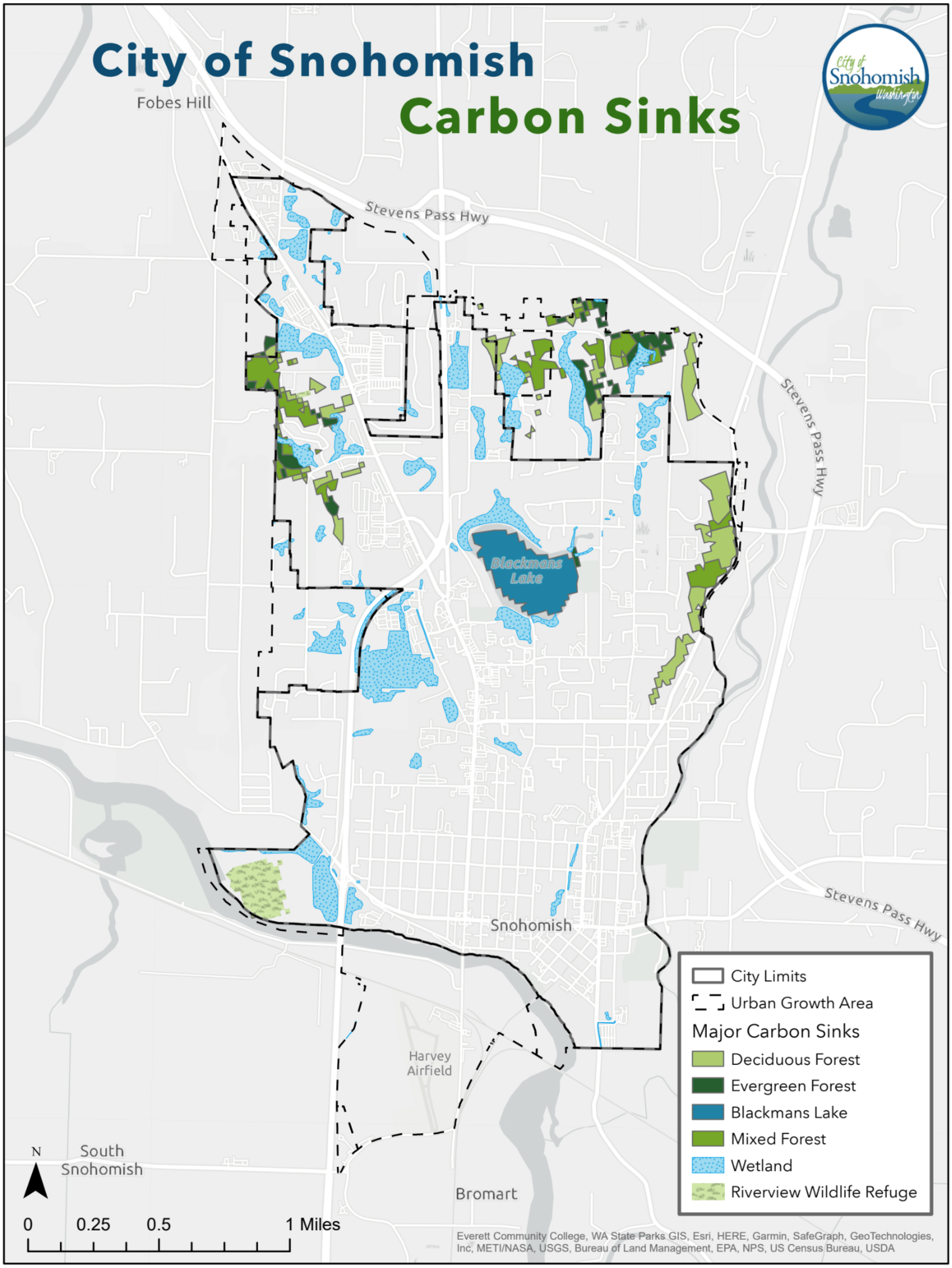


Figure 8.2: Map of City of Snohomish major carbon sinks by land cover type

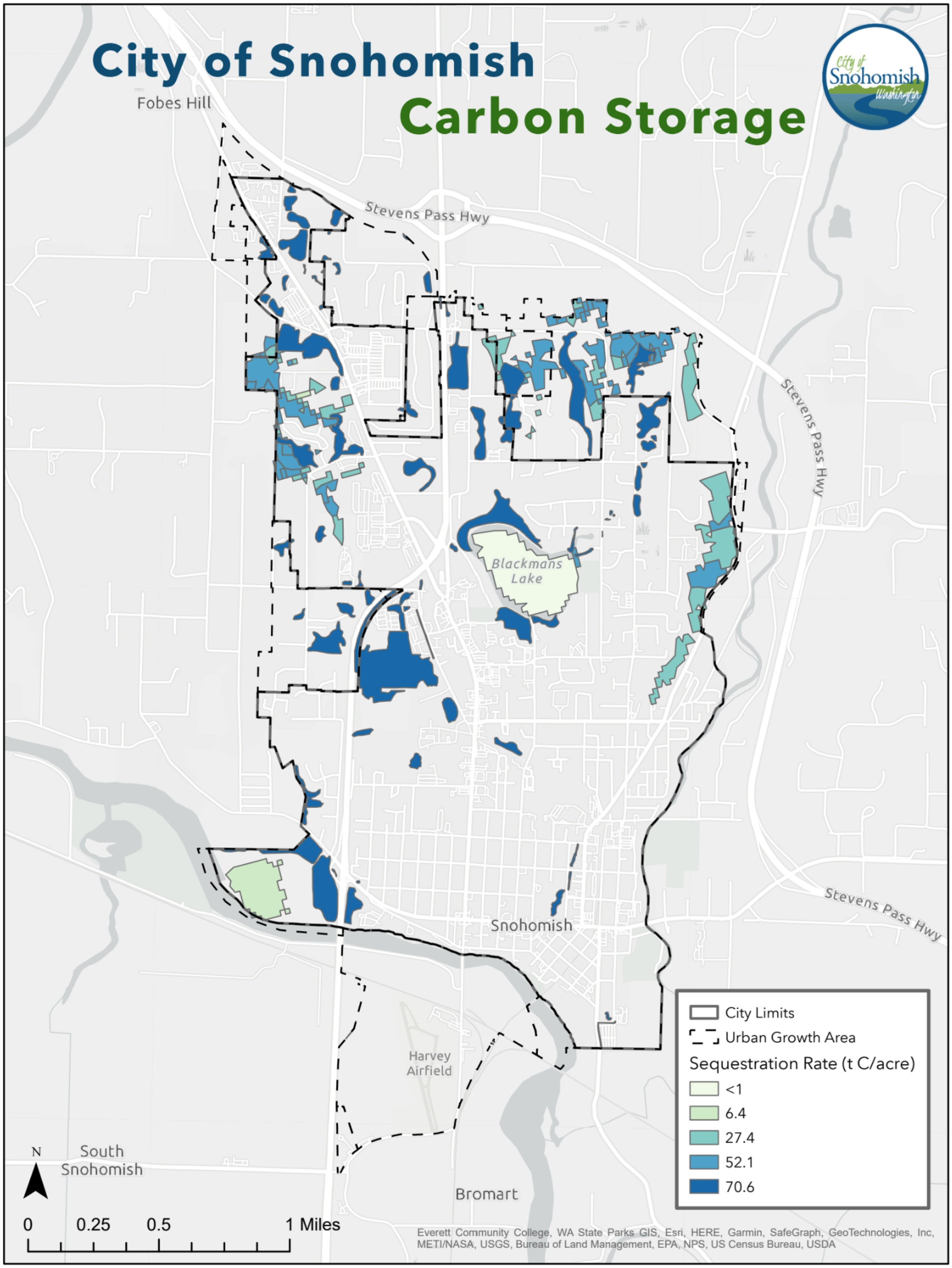


Figure 8.3: Map of City of Snohomish carbon storage sequestration rates of major carbon sinks

Limitations

The analysis of Blackmans Lake is our least specific estimate of carbon sink potential, relying on global-scale analyses of freshwater lake carbon sequestration. We had hoped to find relevant literature on shallow freshwater lakes in the Pacific Northwest, but were unable to. Additionally, specific hydrologic features such as lake characteristics, watershed dynamics, and eutrophication have significant implications for the lake's carbon sink potential. Being unable to take these features into account, we used the available high level figures for our analysis, however, this could have resulted in a significant underestimation of the lake's actual carbon storage potential. For this reason, the lake is still included as a major carbon sink, despite its very low total storage number from our results.

The carbon sequestration rates and storage estimates, tables, and figures from our analysis are intended to provide a conservative, rough estimate of the amount of carbon that *could* be stored in the City's natural lands. These estimates were based only on available data and on a literature review of determined rates of similar land cover types. Our analysis did not include all types of land cover within the City and should not be taken as a conclusive accounting of the local carbon cycle. Additionally, carbon sequestration rates cannot be accurately determined without conducting field measurements and accounting for wetland and forest characteristics, including age and species of vegetation, wetland type, hydrology, soil depth and content, etc., which were out of the scope of this high-level inventory.

Discussion

Climate change impacts, especially warmer temperatures and changes in the precipitation regime, can reduce carbon storage and turn carbon sinks into sources of carbon emissions (Mitsch et al 2013, Moomaw 2018, and Zhu et al 2010). These findings have important policy implications and can help the City prioritize resources and craft the most effective management strategies. Table 8.2 (below) describes in greater detail the most important findings and policy implications.

Table 8.2: Best Available Science and Policy Recommendations Matrix

		Best Available Science	Policy Recommendation
Carbon Sequestration & Storage	Trees & Forests	Urban trees typically sequester less carbon than trees in a natural forest (Nowak et al 2013).	Protect forest patches, plant trees in patches rather than standalone trees, provide deeper planting wells to allow for more expansive root growth and higher below ground carbon storage.
		Evergreen trees provide more carbon storage long term (100+ years) while deciduous trees provide more efficient and immediate carbon storage. Mixed forests have the greatest carbon sequestration potential (Dushku et al .	Plant a mix of both evergreen and deciduous trees to maximize overall carbon storage.
	Wetlands	Most wetlands are net carbon sinks, *despite methane releases* (Mitsch et al 2013 and Marurcyzk and Brooks 2018).	Preserve, restore, and create new wetlands.
		Disturbed and degraded wetlands can become carbon sources rather than sinks, especially if drained or hydrology disrupted (Moomaw 2018, Zhu et al 2010, and Nahlik and Fennessy 2016)	Protect wetlands from further degradation, including against filling, erosion, and disruptions to hydrology.
		Restored wetlands become net sinks within a few years, once 55% vegetation coverage is attained (Valach et al 2021).	Restore wetlands and design planting plans to maximize carbon sequestration potential.
Climate Change Impacts	Trees & Forests	Drought will stress trees reducing growth and carbon sequestration, also leaves trees more susceptible to disease/insects leading to higher tree mortality resulting in carbon emission (Zhu et al 2010).	Prioritize urban tree health by watering street trees during extreme droughts, monitoring for disease/insect outbreaks in forest patches, and adaptively managing.
		More intense rain events can lead to erosion and landslides and tree/forest loss resulting in carbon emission (Zhu et al 2010).	Plant more trees to stabilize steep slopes and build resilience against erosion.
	Wetlands	Drought will leave wetlands susceptible to drying which leads to carbon emission as aquatic vegetation dies and as oxygen spurs decomposition in previously anerobic soils (Moomaw 2018).	Restore wetlands, riparian, and forest areas, including upper watershed, to increase water residence time on the landscape, improving resilience to drought.
		More intense rain events can lead to erosion and vegetation loss resulting in carbon emission (Mitsch et al 2013)	Mandate larger vegetated wetland and stream buffers to slow storm water and protect against wetland erosion and degradation.
		Changes in climate patterns can favor invasive species which can outcompete native wetland plants, lead to filling in of aquatic areas, resulting in carbon release in previously anerobic areas (Mitsch et al 2013).	Monitor and adaptively manage invasive species and educate the public on how to limit the spread of invasives to wetlands and streams.

Conclusion

Our carbon storage inventory tables and maps are intended to provide a conservative, rough estimate of the amount of carbon that *could* be sequestered in the City's natural lands. It does not include all types of land cover within the city, and should not be taken as a conclusive analysis of the local carbon cycle. By providing estimates of carbon sequestration rates by land cover, such as wetlands or forest, we hope to have illustrated the relative potential of different natural lands to mitigate Snohomish's greenhouse gas emissions. Protecting, expanding, and enhancing Snohomish's carbon sinks will also provide co-benefits in the form of other ecosystem services that build resilience to climate change impacts.

To build on this work, there are several potential avenues for further research that we suggest investigating:

- Collect information on the specific characteristics of wetlands present within Snohomish's borders and determine the exact category of wetland carbon sequestration potential from Marzurczyk and Brooks that would match local conditions.
- Partner with the University of Washington or similar institutions to develop more accurate estimates of local terrestrial carbon sink potential and opportunities for expansion of forested areas.
- Incorporate the City's tree inventory data when complete, along with data from parks and other vegetated areas for a more complete picture of total carbon storage.
- Identify opportunities to expand land cover such as wetlands and forest through land trusts, parkland, and conservation corridors.

Methods

Section 1 Methods: ICLEI GHG Scope 2 Community Inventory

Method Type: Qualitative and quantitative

Sub-Methodologies:

1. Landfill gas contribution by Snohomish

$$LFGsno = LFGtotal(Wsno/Wtotal)$$

$$8,294,979.05 = 3,150,898,983 \times (6028 \div 2289773)$$

This is how I calculated the landfill gas emissions attributable to Snohomish, as Republic Services serves many towns. LFG=Landfill gas, W=landfill waste, sno=Snohomish

2. LFG flaring contribution by Snohomish

$$LFGFsno = LFGFtotal(Wsno/Wtotal)$$

$$97,702.53 = 37,112,910 \times (6028 \div 2289773)$$

This is how I calculated the landfill gas emissions generated by flaring attributable to Snohomish, as Republic Services serves many towns. LFGF=Landfill gas flared, W=landfill waste, sno=Snohomish

3. Refrigerant estimate

$$REFsno = REFsnoco \times (POPsno \div POPsnoco)$$

$$5,482 = 440,000 \times (10,200 \div 818,700)$$

This is how I calculated an estimate of emissions from refrigerant gasses attributable to Snohomish. I used the refrigerant emissions calculation from the *Snohomish County Communitywide Geographic Greenhouse Gas Emissions* report and population data to calculate this estimate. REF=refrigerant emissions, POP=population, sno=Snohomish, snoco=Snohomish County

4. 2022 peak one-hour VMT estimates

$$2022VMT = ((2035VMT - 2014VMT)/(2035 - 2014))(2022 - 2014)$$

$$13633 = ((15444 - 12520)/(2035 - 2014))(2022 - 2014) + 12520$$

This is how I calculated an estimate of the peak one-hour VMT in Snohomish using 2014 VMT data and the 2035 VMT estimate.

5. 2022 annual VMT

$$2022AVMT = (2022VMT \times 6 \times 365) + (2022VMT \div 2 \times 18 \times 365)$$

$$74,640,675 = 29,856,270 + 44,784,405$$

This is how I calculated an estimate of annual VMT from the peak one-hour VMT estimate.

6. Science-based target generation
   a. SBTs were generated using a combination of quantitative analysis of Snohomish's GHG inventory/potential reductions and qualitative research on GHG reduction targets and measures.

Background Literature:

a. City of Kenmore Climate Action Plan
   i. Used to understand peer GHG inventory methods and assumptions
      1. Cascadia Consulting Group. (2022). *City of Kenmore Climate Action Plan*. https://www.kenmorewa.gov/home/showpublisheddocument/2209/637898707618200000
b. City of Everett Climate Action Plan
   i. Used to understand peer GHG inventory methods and assumptions
      1. Cascadia Consulting Group. (2020). *City of Everett Climate Action Plan*. https://www.everettwa.gov/DocumentCenter/View/23797/Everett-Climate-Action-Plan-January-2020
c. Briefing on Countywide Planning Policy EN-27: GHG Reduction Targets, EN-29: GHG Reporting, and the King County Regional Emissions Inventory
   i. Used to understand peer GHG inventory methods and assumptions
      1. https://kingcounty.gov/~/media/depts/executive/performance-strategy-budget/regional-planning/GrowthManagement/GMPC-2022/GMPC-Meeting-092822/4a_GMPC_GHG_Targets_and_Measurement_Briefing-Presentation-September_2022.ashx?la=
d. Snohomish County Communitywide Geographic Greenhouse Gas Emissions
   i. Used to understand peer GHG inventory methods and assumptions
      1. https://www.snohomishcountywa.gov/DocumentCenter/View/106055/GHG-Emiss-Inventory-SC19-00-03_GeoEmissionsReport?bidId=
e. Global Protocol for Community-Scale Greenhouse Gas Inventories
   i. Used as a reference for methods
      1. https://ghgprotocol.org/sites/default/files/standards/GPC_Full_MASTER_RW_v7.pdf

f. Local Greenhouse Gas Inventory Tool
   i. Used as a reference for methods
      1. https://www.epa.gov/statelocalenergy/local-greenhouse-gas-inventory-tool
g. Greenhouse Gas Contribution Analysis
   i. Used as a reference for methods
      1. https://icleiusa.org/ghg-contribution-analysis/
h. Greenhouse Gas Inventory for the City of Auburn, Washington
   i. Used to understand peer GHG inventory methods and assumptions
      1. https://mrsc.org/getmedia/092c9b81-087f-40a5-9160-27f417f8ef7e/a9greenhouse.pdf

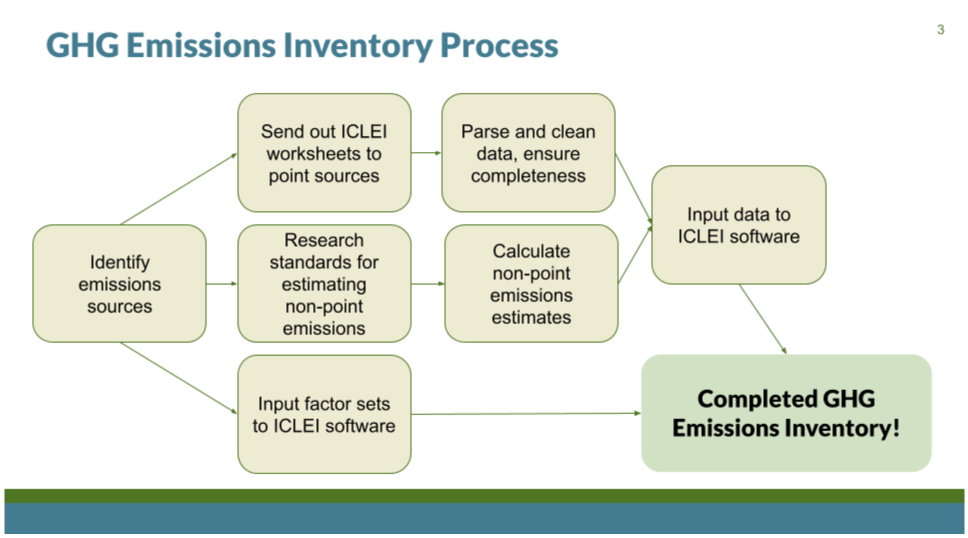
Tools Used:

a. ICLEI ClearPath
b. US Census Data
c. UCSP and ICLEI inventory guidance
d. Google Sheets/Microsoft Excel
e. Lots of emails

Related Appendices:

a. 2022 City of Snohomish GHG Inventory Data
b. Compiled GHG Inventory Data (this will be a folder including all the documents, data .csvs, and other materials for the City to use in future GHG inventories. Will be sent directly to Brooke)

Step-by-step instructions:



Section 2 Methods: Existing Impacts Analysis

2.1: Existing Climate Change Impacts & Historical Trends

Method Type: Quantitative and Qualitative. To understand existing impacts, we looked at trends in precipitation, snowpack, temperature, wildfires, flooding, and extreme heat as these were identified as the most important climate change indicators for the region.

Sub-Methodology: Quantitative analysis: Statistical analysis was used - we utilized the graphs generated through the University of Washington Climate Impact Group's (CIG's) Tableau Northwest Climate Trends analysis tool to show local trends in precipitation, snowpack (represented by snow water equivalent), and temperature. We limited the graphs used to those that CIG had identified as statistically significant.

We utilized data from Stanford University's Environmental Change and Human Outcomes Lab to show average annual days of wildfire smoke experienced by the City in recent years.

In terms of graphing, we created graphs and tables showing flooding events over time from data downloaded from NOAA's NWS website. We quantified flood events in each flood level category for each decade to show decadal shifts in flood return time.

Sub-Methodology: Qualitative analysis: We asked for and received anecdotal evidence of local flooding from City staff at the April 24, 2023 meeting. We also consulted Snohomish County staff to understand flooding dynamics, especially in regard to recent restoration projects in the basin.

Background Literature:

1. IPCC - 6th Edition (2023)
    a. Informed global state of climate change impacts
        i. The Intergovernmental Panel on Climate Change (IPCC). 2023. "Synthesis Report of the IPCC Sixth Assessment Report (AR6) Summary for Policymakers. (AR6)." https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf
2. Department of Commerce Model Guidance for Climate Planning (2023)
    a. Advised on using CIG's climate impacts analysis tools to understand existing impacts
        i. Department of Commerce. 2023. "Climate Element Planning Guidance Draft." https://deptofcommerce.app.box.com/s/bfxuex8uvupyeh7hsfdnlhkpduqgg1cj.
3. Climate Change & Flooding in Snohomish County: New Dynamically-Downscaled Hydrologic Model Projections.
    a. Informed impacts specific to the Snohomish watershed
        i. Mauger, G.S., J. Robinson, R.J. Mitchell, J. Won, and N. Cristea. 2021. "Climate Change & Flooding in Snohomish County: New Dynamically-Downscaled Hydrologic Model Projections." Report prepared for Snohomish County. Climate Impacts Group, University of Washington.

4. Evidence for widespread changes in the structure, composition,and fire regimes of western North American forests
    a. Informed wildfire historical trends
        i. Hagmann, R. K., P. F. Hessburg, S. J. Prichard, N. A. Povak, P. M. Brown, P. Z. Fulé, R. E. Keane, et al. “Evidence for Widespread Changes in the Structure, Composition, and Fire Regimes of Western North American Forests.” Ecological Applications 31, no. 8 (2021): e02431. https://doi.org/10.1002/eap.2431.

Sources / Tools used

a. Climate Impacts Group (PNW Temperature, Precipitation, and SWE Trend Analysis Tool | Office of the Washington State Climatologist
b. National Oceanic & Atmospheric Administration (NOAA), National Weather Service National Weather Service Advanced Hydrologic Prediction Service - Historic Crests Snohomish & Pilchuck
c. Microsoft Excel to graph historical flood data for the Snohomish & Pilchuck Rivers
d. Partnership between NPR and Stanford’s Environmental Change and Human Outcomes Lab (Dangerous Air: We Mapped The Rise In Wildfire Smoke Across America. Here’s How We Did It - capradio.org)

Step-by-step Process: Precipitation, Snowpack (SWE), and Temperature

Step 1: Open UW CIG’s Tableau Northwest Climate Trends Tool

Step 2: Click on Everett station (closest to Snohomish)

Step 3: Change “Variable Selection” to look at each, . Change “Time Frame” to look at each. “Add to graph” = Trendline. Download graph for each variable selection labeled with “S”.

a. Change Tab at top to perform Steps 1-3 with the other indicators: Precipitation and Snow Water Equivalent

Step-by-step Process: Flooding

Step 1: Download historical flood data from NOAA NWS website (listed above)

a. Click on Show more Historic Crests
b. Copy and paste entire record to Excel
c. Separate stage level (ft) data from date
d. Values marked “**(P)**: Preliminary values subject to further review” were included

Step 2: Use Excel to create a scatter plot of historical flood events over time

a. Plot recorded stage level (ft) on the y-axis and the date on the x-axis
b. Add horizontal lines showing flood stage levels (flood, moderate, major)

Step 3: Using graphs from Step 2, count the number of events per flood stage level per decade and use that data to create a table showing the number of events per flood stage level per decade.

2.2: Urban Heat Island Analysis

Method Type: Quantitative and Qualitative

Sub-Methodology:

This analysis was a desktop data processing exercise. Satellite imagery of the City of Snohomish captured by the USGS and NASA LANDSAT 8 (L8) Satellite was taken from the evening of a warm summer day (July 28, 2022). The satellite has two sensors, the Operation Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). The red and near-infrared bands of the OLI (Band 4 and 4) and Band 10 of the TIRS were processed according to the method published by Avdan et. al. to determine surface temperature across the extents of the image.

The data retrieved from LANDSAT was processed in GIS using the method published by Avdan et. al. to determine the land surface temperature across the extents of the raster image (which included the City of Snohomish and the surrounding area). The land surface temperature was then compared to a reading of ambient air temperature measured in the City of Snohomish for the same date and time stamp. This created a new raster in which every square represents the ratio of surface temperature to ambient air temperature. This raster was then multiplied by different ambient air temperatures (90, 95, 100, 105 degrees fahrenheit) to develop rasters showing the surface temperature on a day where the ambient temperature reaches those elevated temperatures.

Background Literature:

a. United States Geological Survey. Landsat 8 (L8) Data Users Handbook. Version 5.0. https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/LSDS-1574_L8_Data_Users_Handbook-v5.0.pdf
b. Avdan, U. and Jovanovska, G. (2016). "Algorithm for Automated Mapping of Land Surface Temperature Using LANDSAT 8 Satellite Data", *Journal of Sensors*, vol. 2016, Article ID 1480307. https://doi.org/10.1155/2016/1480307
c. Moore, C. (2017). *Turning Up the Heat: Urban Heat Islands in Snohomish County* [Master's Thesis, University of Washington]. http://hdl.handle.net/1773/39183
d. Roy, S., Roy, R., Passalacqua, C. 2021. “Equity-Based Community Greening Program Task 1.5 – Urban Heat Island Assessment,” Weston and Sampson.

Data Sources and Tools:

a. Satellite imagery from LANDSAT 8 (available through the USGS EarthExpolorer tool); image utilized was from July 28, 2022 at 18:05 pm
b. ArcGIS Pro software, available through the UW enterprise
c. Historic ambient air temperature data for the City of Snohomish collected from the KWASNOHO49 weather station (Source: weatherunderground)

Step-by-Step Process:

Step 1: Download Level One Landsat 8 Data for the location, date, and time of interest, picking an image with minimal cloud/smoke cover (best practice is to use an image from the evening or night of a hot day, when hot surfaces will have absorbed the heat of the day).

Step 2: Import images from Band 10, Band 4, and Band 5 into ArcGIS Pro.

Step 3: Open metadata to find the constants needed to perform the calculations:

- Need M(L) - band-specific multiplicative rescaling factor (listed for radiance for band 10) - usually 0.000342
- Need A(L) - band-specific additive rescaling factor (for radiance for band 10) - usually 0.1
- Need K1 - thermal constant for band 10 - 1321.08
- Need K2 - second thermal constant for band 10 - 777.89

Step 4: Use the Raster Calculator function in ArcGIS Pro to calculate top of atmosphere (TOA) Spectral Radiance using the following formula:

$$L\lambda = M_L * Q_{\mathrm{cal}} + A_L \cdot$$

Step 5: Use the Raster Calculator function in ArcGIS Pro to convert Radiance to At-Sensor Temperature (Brightness Temperature or BT) using the following equation (which gives results in degrees celsius):

$$\mathrm{BT} = \frac{K_2}{\ln\left[\left(K_1/L\lambda\right) + 1\right]} - 273.15,$$

Step 6: Use the Raster Calculator function in ArcGIS Pro to calculate Normal Difference Vegetation Index (NDVI) to determine general vegetation condition, which is based on the Near-Infrared band (Band 5) and red band (Band 4), using the following equation:

$$\mathrm{NDVI} = \frac{\mathrm{NIR}\,(\mathrm{band}\ 5) - R\,(\mathrm{band}\ 4)}{\mathrm{NIR}\,(\mathrm{band}\ 5) + R\,(\mathrm{band}\ 4)},$$

Step 7: Use the Raster Calculator function in ArcGIS Pro to calculate the proportion of vegetation (Pv) using the following equation, where NDVIs = minimum NDVI value calculated above, and NDVIv is the maximum value:

$$P_v = \left(\frac{\mathrm{NDVI} - \mathrm{NDVI}_s}{\mathrm{NDVI}_v - \mathrm{NDVI}_s} \right)^2 .$$

Step 8: Use the Raster Calculator function in ArcGIS Pro to calculate land surface emissivity using the following equation:

$$\boldsymbol{\varepsilon = 0.004 * P_v + 0.986}$$

Step 9: Use the Raster Calculator to calculate Land Surface Temperature using the following equation:

LST = (BT / (1 + (0.00115 * BT / 1.4388) * Ln(ε)))

Step 10 (optional depending on context): Use Raster Calculator to convert LST from degrees celsius to degrees fahrenheit.

LST(°F) = LST*(9/5) + 32

Step 11: determine ratio of surface temperature to ambient air temperature

- Find the ambient air temperature (AAT) for the location, date, and time that the LANDSAT image was taken. This can be a single reading or, if available, an average of nearby weather stations' readings for the appropriate date and time. Historical weather data for local weather stations is available on wunderground.com
- Determine the ratio using the following formula:
  - Ratio = LST(°F)/AAT

Step 12: Determine Surface Temperature Heat Maps for different ambient air temperatures (90°F, 95°F, and 100°F is typical). For a 90°F day:

- LST(90) = Ratio*90
  - Note that "Ratio" is the raster developed in the previous step
- Repeat for all ambient air temperatures of choice

Step 13: Adjust symbology of all output rasters so that the minimum and maximum values are the same. This will ensure that each component of the color ramp of the raster corresponds to the same temperature value for all outputs, making them easier to compare to one another. Use the minimum value of the lowest temperature day for the minimum, and the maximum of the highest temperature day for the maximum. Use the color ramp that spans from blue to red to symbolize the heat maps.

2.3: Wildfire & Smoke

Step-by-step Process: Wildfire and Wildfire Smoke

Step 1: Open NPR's and Stanford Environmental Change and Human Outcomes Lab's Dangerous Air: We Mapped The Rise In Wildfire Smoke Across America. Here's How We Did It - capradio.org Report and Map.

Step 2: Enter "Snohomish, Washington, United States" into the "State, City, Zip, Address" search box.

Step 3: Click on blue pin that appears on Snohomish on the map.

2.4: Vulnerable Groups & Environmental Justice

Method Type: Qualitative.

Sub-Methodology: Mapping exercise: We researched the potential locations of "populations of concern" and overlaid these with the urban heat island (UHI) map (methods for the UHI map can be found separately below).

We determined that limited 2020 US Census data exists at the block group level in the City of Snohomish, which prevented us from mapping populations of concern at the block group level. Due to this, we chose to define the characteristics of vulnerable populations and then assemble a list of potential establishments where these populations are likely to be present for prolonged periods of time.

Background literature:

US EPA resources were used to define vulnerable populations, environmental justice, and to acquire a list of populations of concern. We sifted through US Census Bureau data to determine what level of data was available for the City of Snohomish, as discussed above.

a. United States Environmental Protection Agency. 2017. "Climate Impacts on Human Health." Accessed April 12, 2023. https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-human-health_.html#Populations%20of%20concern.
b. United States Environmental Protection Agency. 2023. "Environmental Justice". Accessed May 24, 2023. https://www.epa.gov/environmentaljustice
c. United States Census Bureau. 2020 American Community Survey 5-Year Estimates. https://data.census.gov/advanced.

Sources/tools used:

a. Google MyMaps
    i. Used to search for establishments where populations of concern are likely to be present for prolonged periods of time.
b. ArcGIS Pro
    i. Used to

Step-By-Step Process:

Step 1: Search for potential locations of populations of concern

a. The EPA has identified seven primary populations of concern when considering the risks of climate change: older adults; people with disabilities; people with chronic medical conditions; children; pregnant women; communities of color, low-income people, immigrants, and limited English proficiency; certain occupational groups like outdoor workers, paramedics, firefighters, transportation workers (EPA 2017).
b. We brainstormed potential search terms that could be used to find locations where these types of groups might be present for prolonged periods of time. Google MyMaps was used to search for the following search terms and establishments and pin them onto the map. This is not an exhaustive list of search terms that were used, but it represents the types of terminology used:
    i. Senior Center, Nursing Home, Assisted Living, Eldercare
    ii. High school, elementary school, preschool, kindergarten, daycare, childcare
    iii. Urgent care, medical care, pregnancy, birthing center
        1. Note: we opted to include medical centers that were larger or offered numerous services (rather than small, specialized offices)
    iv. Apartments, low-income housing
c. Locations were grouped into layers of similar categories and named accordingly.

Step 2: Export Google MyMap as KML, import to ArcGIS Pro

a. The Google MyMap was exported as a KML and saved.
b. We opened the previously prepared urban heat island ArcGIS file and added the KML to this using the following steps:
    i. Go to ArcToolbox > Conversion Tools > From KML > KML to Layer.
c. Once the new layer was populated on the map, the symbology was edited to create different colored dots, and the dots were re-labeled according to the categories.

Section 3 Methods: Climate Projections for the City of Snohomish

Method Type: Mixed

Sub-Methodology: Qualitative analysis: We began by downloading all data from the Climate Impacts Group's Mapping for a Resilient Washington webtool related to drought, extreme heat, flooding, extreme precipitation, sea level rise, and wildfire and organized it into a spreadsheet so we could view all data side-by-side.

We identified relevant data that considered the two Representative Concentration Pathways (RCP) emissions scenarios (4.5 as the low emissions scenario, 8.5 as the high emissions scenario) with a date range between 2020-2049, 2050-2079, and 2060-2089 to correspond with 2050 and 2070 benchmarks in local, regional, and state policy (see *Appendix B: Snohomish Climate Projections* (Section 3)). The shorter time frame of 2030-2049 was selected to align with the Comprehensive Plan update, while the longer time frame of 2060-2079 was chosen to reflect the lifespan of a current adult living in the City. Representative Concentration Pathways (RCP) are used internationally, such as by the United Nations' Intergovernmental Panel on Climate Change (IPCC), to model potential future climate scenarios based on models for future concentrations of GHG. The IPCC defined four pathways (RCP 2.6, 4.5, 6.0, and 8.5) to forecast different climate futures depending on GHG trajectories. The UW Climate Impacts Group uses RCP 8.5 to show a higher emissions scenario and RCP 4.5 to show a low emissions scenario (though IPCC used RCP 4.5 as an intermediate emissions scenario in their 2014 report).

We prioritized drought, flooding, heat, precipitation, and wildfire in relation to smoke as potential hazards to focus our inquiry as those hazards showed the most significant projected change over time and therefore the most significant projected impact. We mapped the interaction of hazards and sectors to visualize climate nexus. Our process and findings were documented in narrative form (see Section 3: Climate Projections for the City of Snohomish).

Background Literature:

a. IPCC - 6th Edition (2023)
    i. Informed RCP framing
b. Department of Commerce Model Guidance for Climate Planning (2023)

How the sub-methods were used to assemble the section:
Department of Commerce Draft Guidelines recommend using the University of Washington's Climate Impacts Group's webtool to delineate hazard, sector, and impact interfaces.

Sources/tools used:

a. University of Washington Climate Impacts Group webtool
b. Adobe Illustrator to make the sector webs.
c. Google Sheets to compile the data from CIG.

Step-by-step Process:

Step 1: Downloaded data from Climate Impacts Group's *Mapping for a Resilient Washington* webtool related to drought, extreme heat, flooding, extreme precipitation, sea level rise, and wildfire.

Step 2: Identified relevant data that considered RCP emissions scenarios (4.5 as the low emissions scenario, 8.5 as the high emissions scenario) with a date range between 2020-2049 and 2050-2079.

Step 3: Prioritized drought, flooding, heat, precipitation, and wildfire in relation to smoke as potential hazards to focus our inquiry.

Step 4: Mapped the interaction of hazards and sectors to visualize climate nexus.

Step 5: Documented process and findings in narrative form (see Section 3: Climate Projections for the City of Snohomish).

Section 4 Methods: SWOT Analysis Related to Climate Protection

Method Type: Qualitative

Sub-Methodology: <u>Quantitative analysis:</u> Statistical analysis gathered during Section 3

Sub-Methodology: <u>Other:</u> Key city assets were compiled and sorted into three categories: social, environmental, and economic. The C40 risk assessment tool was used to assess the risks and vulnerabilities of the key assets.

These were used to create the Risk Matrix and Risk assessment rationale.

Background Literature:

a. C40 rapid risk assessment
b. Snohomish County Hazard Mitigation Plan
c. City of Tacoma Hazard Mitigation Plan

How the sub-methods were used to assemble the Section:
The key assets were sorted and the C40 framework applied to produce a risk matrix prioritizing assets into four categories from "High concern" to "least concern." The UW CIG tool was used to inform flooding risks for certain assets.

Sources/Tools Used:

a. University of Washington Climate Impacts Group webtool
b. Risk Factor
c. Google Slides to generate Risk Matrix, Workbook, and slides for presentation

Step-by-step Process:

Step 1: We began by brainstorming assets in the community. We categorized them into Community, Environment, and Economy.

Step 2: Next, we determined what hazards would affect each asset we identified.

Step 3: We created a rough "risk calculation table" where each asset was graded (High, Medium, Low, or Mixed) on the following categories:

- **Impact-** The results that follow from damage to or loss of an asset due to a hazard. Can be exacerbated by non-climate stressors such as growth or land use
- **Exposure-** The presence of assets in places where they could be adversely affected by hazards
- **Sensitivity-** The degree to which a system, population, or resource is or might be affected by hazards
- **Adaptive capacity-** The ability of an asset to withstand and adjust to a climate impact

- **Risk-** A combination of the following categories

Step 4: We listed our rationale for each individual grade.

Step 5: We visualized risk ratings on a risk matrix with an X axis of “severity” and a y axis of “likelihood”

- “Likelihood” = Exposure + Hazard probability (consult CIG data)
- “Severity” = Impact + Sensitivity + Adaptive capacity

Step 6: From the Risk matrix, we created a rough priority ranking with the top priorities being furthest to the top left and the lowest priorities being to the far right and/or bottom. Ideally, four tiers of priority should be established.

- Highest concern
- 2nd tier
- 3rd tier
- Least concern

Section 5 Methods: Climate Change Regulatory Framework for the City of Snohomish

Method Type: Qualitative

Step-by-step Process:

Step 1: We reviewed selected policies and regulations from Washington State, Puget Sound Regional Council, Snohomish County, Puget Sound Clean Air Agency, and Puget Sound Clean Air Agency and to identify climate or carbon reduction policies and regulations that frame the climate policy environment the City of Snohomish is operating within.

Step 2: We then indicated with an "X" if these policies and regulations align with the 11 sectors of the Model Climate Element (Agriculture and Food; Buildings & Energy; Cultural Resources & Practices; Economic Development; Ecosystems; Emergency Management; Health & Well-Being; Transportation (roads, bridges, multimodal); Waste Management; Water Resources; and Zoning and Development), adding five of our own elements we consider important, but were not present in the Model Climate Element (Equity/Vulnerable Communities; Greenhouse Gas Emissions Reductions; Jurisdictional/Regional Coordination; Adaptation/Resilience; and Mitigation/Reduce Emissions).

Step 3: We then analyzed the interactions between different goals, policies, and regulations within each sector to identify possible synergies or overlaps in policies. We prepared a report to illustrate the regulatory framework from the state, regional, and county levels to inform Section 7's policy recommendations.

Policy/Documents Reviewed:

1. Snohomish County 2020 Hazard Mitigation Plan (HMP)
    a. City of Snohomish 2015 Annex to HMP
2. Puget Sound Clean Air Agency
3. Snohomish County 2016 Comprehensive Plan
4. Puget Sound Regional Council Vision 2050
5. HB1181: Climate Change - Planning
6. SB5126 2020: WA Climate Commitment Act; Cap and invest system for GHG emissions
7. HW 2311 2019: Set new GHG emissions targets; Applies to whole state and to state agencies
8. SB5116 2019 - Clean E Transportation Act; Carbon neutral electricity by 2035; Carbon zero electricity by 2045
9. Snohomish County Sustainable Operations Action Plan (SOAP)
10. Snohomish County 2018 Greenhouse Gas Emissions Inventory for Government Operations
11. WA Shoreline Management Act of 1971

Background Literature:

1. Department of Commerce Model Guidance for Climate Planning (2023)
    a. Informed the 11 elements

2. MSRC Local Government Climate Change Documents
    a. Informed climate change documents to review
3. Dr. Jan Whittington’s University of Washington Urban Climate Solutions class informed which Washington State policies and regulations were important to receive.

Section 6 Methods: Snohomish Comprehensive Plan: Environmental Protection Element Gap Analysis

Method Type: Qualitative

Sub Methodology: Qualitative analysis: Creating goals based on well-researched guidelines and understanding the ways in which the Environmental Plan falls short of the goal. The goal of this approach is to understand areas for improvement in the plan.

How sub-methods were used in this Section
The Department of Commerce guidance was consulted in order to create criteria for an effective comprehensive plan. In order to then apply this to the Environmental Protection Element we needed to identify whether or not the plan met the suggested criteria and where it did not make note of the limiting language and/or lack of language. We then reviewed the broader policy for goals, strategies, or policies that might help to fill the gaps in the Element or weaken the approach towards broader environmental protection and climate action.

Step-by-step Process:

Step 1: Read through the Department of Commerce model climate element.

Step 2: Pull out main themes from sections of documents and craft goals from themes.

Step 3: Read through Environmental Protection Element with attention to shortcomings as laid out by the Department of Commerce.

Step 4: Understand what parts of the existing plan do not meet the criteria created.

a. This is an inherently qualitative method so it is helpful to first list out the most blatant shortcomings.

Step 5: Review broader plan for goals, strategies, and policies that might cover gaps listed in the Environmental Protection Element.

Step 6: Review other Elements for policies and gaps that could be related to the scope of the Environmental Protection Element.

Step 8: Draft brief conclusions.

Background Literature:

a. Washington State Department of Commerce Model Climate Element

Section 7 Methods: Draft Goals and Policies for Climate Element

Method Type: Qualitative

Sub-Methodology: Subjective Ranking: based on a set of criteria considering existing conditions, research into future climate hazards, feedback from city personnel, financial costs, relationship to State and County climate goals, and feasibility considering the resources of a small city.

How sub-methods were used in this Section
The Department of Commerce guidance was used as a baseline for policy language. The first round of narrowing utilized four categories based on prior research, background knowledge, and on-the-ground experiences. The second round of narrowing folded in knowledge from additional research from existing guidance at the State or County levels. The third round of narrowing condensed language and goal objectives for a diverse yet palatable menu of policies for the City of Snohomish to consider.

Please list the specific names of the appendix documents you have created (or are creating)

a. Menu of Goals & Policies (Department of Commerce)
b. Recommended Goals & Policies (Snohomish Studio)

Step-by-step Process:

Step 1: 1st Round Goal - Reduce: eliminate extraneous policies recommended by the Department of Commerce's comprehensive guidance.

a. Criteria are as follows:
    i. This policy is relevant to the City of Snohomish
        1. 0 - Strongly Disagree; 1 - Disagree; 2 - Neutral; 3 - Agree; 4 - Strongly Agree
    ii. This measure/policy/action will influence identified priority hazards (flooding/extreme precipitation, drought/extreme heat, and/or wildfire/smoke)
        1. 0 - Strongly Disagree; 1 - Disagree; 2 - Neutral; 3 - Agree; 4 - Strongly Agree
    iii. City staff have expressed interest in this measure/policy/action.
        1. 0 - Strongly Disagree; 1 - Disagree; 2 - Neutral; 3 - Agree; 4 - Strongly Agree
    iv. This measure/policy/action is feasible considering the resources of a small community.
        1. 0 - Strongly Disagree; 1 - Disagree; 2 - Neutral; 3 - Agree; 4 - Strongly Agree
    v. Department of Commerce: "Highest Priority Measures"
        1. YES = Red; NO = empty
b. Elimination Qualifications:

   i. Any goals/policies with two or more ‘0’ rankings under Criteria 1
   ii. Discuss goals/policies with one or more ‘0’ rankings under Criteria 1
   iii. Discuss goals/policies with rankings at or below 9pts (of a potential 16)

Step 2: 2nd Round Goal: Condense

c. Apply findings from State and County plans and regulations to identify areas for which the City of Snohomish is specifically responsible
d. Rank relative importance of policies within the goals identified by the Department of Commerce

Step 3: 3rd Round Goal: Specify

e. Refine the wording of policies to be specific to the City of Snohomish
f. Provide contextual rankings of final list of condensed policies
   i. Impact: If implemented, what level of relative impact will this have on the City of Snohomish and its networks?
      1. Low; Medium; High
   ii. Level of Investment / Cost: How much money is expected to be allocated to fulfill the policy measure?
      1. $ = Low level of investment / projected cost; $$ = Medium level of investment / projected cost; $$$ = High level of investment / projected cost; Variable = Range of investment / projected cost
   iii. Co-Benefits: associated co-benefits identified by the Department of Commerce in the Climate Planning Guidance
   iv. Implementation Timeframe: How long will the policy take to develop and implement?
      1. Short (<5 years); Medium (5-10 years); Long (>10 years); Variable = range of potential timelines for implementation
      2. Implementation may also be an ongoing matter
   v. Feasibility Considerations: In a short narrative form, what are some items that should be considered that are not within the scope of the previous assessments, or support and qualify policy dimensions?

Step 4: Compile final list of policies in document that includes, for each sector:

g. Goal
   i. Co-benefits
h. Policy
   i. Impact
   ii. Co-benefits
   iii. Level of Investment / Projected Cost
   iv. Implementation Timeframe

v. Feasibility Considerations

Sources/Documents Reviewed:

a. Washington State Department of Commerce - Model Climate Element, Appendix C: Climate Element Workbook
    i. Rationale: Completing steps in this workbook correlates with State guidance and can be directly comparable with independent City efforts
b. King County 30-Year Forest Plan
    i. Rationale: This planning document contains language borrowed for the Ecosystem Sector proposed policies regarding equity and urban forests.

Background Literature:

a. Washington State Department of Commerce - Model Climate Element (Draft for Public Review)
    i. Rationale: This is poised to be *the* climate planning guide for communities after the current Legislative Session [HB 1181 (passed); SB SB 5203 (pending as of May 16, 2023)]
b. Climate Action Plan (City of Kenmore)
    i. Rationale: This document is a good example of synthesizing climate data and translating into goals and policies related to climate change in the City of Kenmore.

Section 8 Methods: Carbon Sinks Identification & Storage Inventory

Method Type: Quantitative & Qualitative

Sub-Methodology: Quantitative analysis: collected carbon sequestration rates from academic literature, used GIS to create shapefiles of carbon sink categories from City GIS files and an available national land cover database, and applied sequestration rates to existing land cover to generate a rough estimate of total carbon storage.

Sub-Methodology: Qualitative analysis: surveyed the available scientific, peer-reviewed literature on carbon sequestration and expected climate change impacts on carbon sinks, as well as potential adaptation strategies.

How Sub-Methods Were Used:

We used the sequestration rates gathered from the previously mentioned sources to provide the City estimates of sequestration taking place on various land cover types. We used the qualitative literature review to compile the best available science on carbon sequestration potential based on land cover type, climate change impacts specific to carbon sinks, and adaptation strategies. This information will help inform policy and planning efforts, particularly in terms of land use choices, and the prioritization, management, and protection of critical carbon sinks.

Step-by-Step Process: Identifying Sequestration Rates

Step 1: Use Table 2-2 from Dushku et al (2007) for sequestration rates by forest types to find rates for each NLCD land cover type (Evergreen Forest, Deciduous Forest, Mixed Forest)

a. Use Douglas fir, 40 year old, MID rate to represent Evergreen Forest (132.5 t C/ha)
b. Use Mixed Mesic Forest, 40 year old rate to represent Mixed Forest (161 t C/ha)
c. Divide rates by 2.47105381 to convert hectares (ha) to acres.
d. Multiply rates by 0.8 per suggestion by Nowak et al (2013) to adjust for lower sequestration ability of patches of urban forest and urban trees as compared to natural forests

Step 2: Use Table 2-3 from Dushku et al (2007) for sequestration rates by vegetation type to find rates for each NLCD land cover types found at the Riverview Wildlife Refuge (trees, shrub/scrub, cultivated crops).

a. Use Wet grassland and Shrub/Tree rates to represent sequestration rate of area of wildlife refuge
    i. Take an average of these two rates (5.9 t C/ha + 25.5 t C/ha / 2)
    ii. Divide rate by 2.47105381 to convert hectares (ha) to acres.

Step 3: Calculate rate for Blackmans Lake

a. With limited locally-applicable literature on shallow freshwater lakes, we took a different approach to estimating Blackmans Lake's carbon sink potential. We primarily relied on Toming et al's "Predicted Lake Dissolved Organic Carbon at a Global Scale", a comprehensive dataset based on analysis of freshwater lakes larger than 0.1 km in surface area, which Blackmans Lake exceeds. The authors estimate the global average of dissolved carbon present in freshwater lakes at 3.88mg per liter to the power of negative one, which converts to 0.26 mg of CO_2 per liter.

b. To simplify the math, we then converted liters to cubic meters, which gave us 258 mg of CO_2 per cubic meter. Converting 800 acre feet to cubic meters gave us 986,784 cubic meters, which we multiplied by our CO_2 figure to get 254,590,272 mg dissolved CO_2 within the lake's water.
c. Lastly, we converted to metric tons (tonnes), giving us an estimate of 0.25 tonnes of CO_2 stored within the water of Blackmans Lake.
d. Calculating the amount of carbon stored within sediment would require significantly more information, including detail on the characteristics of the lake's sedimentary layer, which we did not have. Because of the limited data and literature, we decided to leave our analysis of Blackmans Lake at an estimate of dissolved CO_2.

Step-by-Step Process: GIS Mapping

Step 1: Download NLCD Conus 2019 land cover data and open in new ArcGIS Pro project

a. 16 land cover classes applied at 30 meter resolution to create raster, based on Landsat satellite data, created by the Multi-Resolution Land Characteristics (MRLC) Consortium.
b. Compare this raster to Google Earth Pro satellite imagery for validation

Step 2: Add City of Snohomish wetlands shapefile, City boundary, and UGA shapefiles

Step 3: Cut land cover and wetlands to UGA extent

Step 4: Convert land cover raster to polygon

Step 5: Select by attributes only forest land cover types (evergreen, mixed, deciduous) as well as select all land cover types attributed to the wildlife refuge (cultivated crops, barren land, shrub/scrub)

a. Make layer from selected attributes
b. Dissolve by land cover type

Step 6: Dissolve wetlands

Step 7: Merge land cover layer and wetlands layer

Step 9: Add new fields

a. Add field for acres, calculate geometry: US survey acres
b. Add field for carbon sequestration coefficients
c. Add field for total storage, calculate field = acreage x coefficient (sequestration rate)
d. Add field for land cover type

Step 11: Download data from ORNL DAAC NASA Earth Data (see link below in Data Sources/Tools) and add raster to map

a. Compare this carbon storage raster to created map

Step 10: Make maps in ArcGIS Layout

a. Map 1: Carbon Sinks: Symbology: graduated colors: land cover type
b. Map 2: Carbon Storage/Sequestration rates per acre: Symbology: graduated colors: Carbon Coefficients

Data Sources/Tools Used:

a. Marurcyzk and Brooks, 2018 for wetland carbon capture rates
b. USGS National Land Cover Database 2019 - Landcover & Imperviousness (NLCD2019) | Multi-Resolution Land Characteristics (MRLC) Consortium for 30 m raster dataset for mapping land cover types
    i. Downloaded NLCD 2019 Land Cover (CONUS)
c. City of Snohomish shapefile for wetlands used in ArcGIS maps
    i. Shapefile provided by Brooke Eidem, Planning Director, City of Snohomish
d. Snohomish County GIS Open Data | Snohomish County, WA - Official Website (snohomishcountywa.gov) for city boundary and UGA shapefiles for ArcGIS maps
e. ArcGIS Pro 3.1.2 to create Carbon Sink and Carbon Storage maps using above data sources
f. The Nature Conservancy's Resilient Land mapping tool to corroborate identification of carbon sink locations and sequestration rates
g. ORNL DAAC NASA Earth Data https://doi.org/10.3334/ORNLDAAC/1829 to corroborate identification of carbon sink locations and sequestration rates
    i. Used this carbon stock raster dataset in ArcGIS Pro to compare to our results
h. Satellite imagery from Google Earth Pro to corroborate NLCD 2019 land cover classification

Background Literature:

a. Port of Seattle's 2018 PORTfolio Carbon Sequestration Assessment
    i. Informed overall methodology
    ii. Listed sources provided starting place for literature review
    iii. Port of Seattle staff provided the document via email, and provided explanation of methods and advice on overall approach to inventory over zoom call.
b. Wetlands & climate change - Washington State Department of Ecology
    i. Aided in understanding climate change impacts and mitigation strategies
    ii. Listed sources provided additional studies for literature review
c. Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities
    i. https://www.researchgate.net/publication/242751935
d. Carbon fate in lowland rivers.

    i. https://doi.org/10.1038/s41561-021-00849-3
e. Carbon Storage Dynamics of Temperate Freshwater Wetlands in Pennsylvania
    i. https://link.springer.com/article/10.1007/s11273-018-9619-6#auth-Tara-Mazurczyk
f. Wetlands, carbon, and climate change
    i. https://doi.org/10.1007/s10980-012-9758-8.
g. Wetlands in a changing climate: science, policy and management
    i. https://doi.org/10.1007/s13157-018-1023-8
h. Carbon storage in US wetlands
    i. https://www.nature.com/articles/ncomms13835.
i. Carbon storage and sequestration by trees in urban and community areas of the United States.
    i. https://www.fs.usda.gov/nrs/pubs/jrnl/2013/nrs_2013_nowak_001.pdf
j. Snohomish County State of the Lakes Report: Blackmans Lake
    i. https://snohomishcountywa.gov/DocumentCenter/View/17874
k. Predicted Lake Dissolved Organic Carbon at a Global Scale.
    i. https://zenodo.org/record/3452124#.ZGJFFHbMJdh
l. Productive wetlands restored for carbon sequestration quickly become net CO_2 sinks with site-level factors driving uptake variability.
    i. https://doi.org/10.1371/journal.pone.0248398
m. Forest Carbon Stocks and Fluxes from the NFCMS, Conterminous USA, 1990-2010.
    i. https://doi.org/10.3334/ORNLDAAC/1829
n. Estimating the Carbon Footprint of Lakes and Reservoirs
    i. https://www.nalms.org/wp-content/uploads/LakeLine/35-3/Articles/35-3-5.pdf
o. A method for assessing carbon stocks, carbon sequestration, and greenhouse-gas fluxes in ecosystems of the United States under present conditions and future scenarios
    i. http://pubs.usgs.gov/sir/2010/5233/

Works Cited

Avdan, U. and Jovanovska, G. 2016. "Algorithm for Automated Mapping of Land Surface Temperature Using LANDSAT 8 Satellite Data." *Journal of Sensors*, vol. 2016 (1480307). https://doi.org/10.1155/2016/1480307.

Buis, Alan. 2019. “The Atmosphere: Getting a Handle on Carbon Dioxide.” *National Aeronautics and Space Administration (NASA),* October 9, 2019. https://climate.nasa.gov/news/2915/the-atmosphere-getting-a-handle-on-carbon-dioxide/#:~:text=Once%20it's%20added%20to%20the,timescale%20of%20many%20human%20lives.

City of Kenmore. 2022. “Climate Action Plan.” https://www.kenmorewa.gov/home/showpublisheddocument/2209/637898707618200000.

City of Snohomish. 2015. “Annex to Snohomish County Hazard Mitigation Plan.” https://snohomishcountywa.gov/DocumentCenter/View/23982/HMP-Volume-2--Sept-2015-Final?bidId=.

City of Snohomish. 2021. “The Snohomish County Growth Management Act Comprehensive Plan.” https://snohomish.county.codes/CompPlan/.

Community Transit “System Wide Map | Snohomish County Transit.” Accessed April 15, 2023. https://www.communitytransit.org/maps-and-schedules/system-wide-map.

Department of Commerce. 2023. “Climate Element Planning Guidance Draft.” https://deptofcommerce.app.box.com/s/bfxuex8uvupyeh7hsfdnlhkpduqgg1cj.

Department of Commerce. 2023. “Climate Element Planning Guidance Draft - Climate Measures.” https://app.smartsheet.com/b/publish?EQBCT=52e61b597e1241289af0460640cdd0ce.

Dewitz, J., and U.S. Geological Survey (USGS) 2021. National Land Cover Database (NLCD) 2019 Products (ver. 2.0, June 2021): U.S. Geological Survey Data Release. https://doi.org/10.5066/P9KZCM54.

Dushku, A., S. Brown, T. Pearson, N. Martin, S. Petrova, J. Winsten and J. Kadyszewski. 2007. “Carbon Sequestration Through Changes in Land Use in Washington: Costs and Opportunities.” California Energy Commission, PIER Energy-Related Environmental Research. https://www.researchgate.net/publication/242751935.

Ford, W., Fox, J. 2021. “Carbon Fate in Lowland Rivers”. Nat. Geosci. 14, 802–803 (2021). https://doi.org/10.1038/s41561-021-00849-3.

Hagmann, R. K., P. F. Hessburg, S. J. Prichard, N. A. Povak, P. M. Brown, P. Z. Fulé, R. E. Keane, et al. “Evidence for Widespread Changes in the Structure, Composition, and Fire Regimes of Western North American Forests.” Ecological Applications 31, no. 8 (2021): e02431. https://doi.org/10.1002/eap.2431.

King County. 2021. “King County 30-Year Forest Plan.” https://your.kingcounty.gov/dnrp/library/water-and-land/forestry/30-year-forest-plan/30-year-forest-plan.pdf.

King County. 2022. “Briefing on Countywide Planning Policy EN-27: GHG Reduction Targets, EN-29: GHG Reporting, and the King County Regional Emissions Inventory.” https://kingcounty.gov/~/media/depts/executive/performance-strategy-budget/regional-planning/GrowthManagement/GMPC-2022/GMPC-Meeting-092822/4a_GMPC_GHG_Targets_and_Measurement_Briefing-Presentation-September_2022.ashx?la=en.

Manangan, A., Uejio, C., Sahal, S., Schramm, P., Marinucci, G., Brown, C., Hess, J., Luber, G. “Assessing Health Vulnerability to Climate Change: A Guide for Health Departments.” Centers for Disease Control and Prevention. https://www.cdc.gov/climateandhealth/pubs/assessinghealthvulnerabilitytoclimatechange.pdf.

Marurcyzk, Tara, Brooks, Robert P. 2018. “Carbon Storage Dynamics of Temperate Freshwater Wetlands in Pennsylvania.” Wetlands Ecology and Management, Vol 26, 893-914. https://link.springer.com/article/10.1007/s11273-018-9619-6#auth-Tara-Mazurczyk

Mauger, G.S., J. Robinson, R.J. Mitchell, J. Won, and N. Cristea. 2021. “Climate Change & Flooding in Snohomish County: New Dynamically-Downscaled Hydrologic Model Projections.” Report prepared for Snohomish County. Climate Impacts Group, University of Washington.

Mitsch, William J., Bernal, Blanca, Nahlik, Amanda M., Mander, Ulo, Zhang, Li, Anderson, Christopher J., Jørgensen, Sven E., and Brix, Hans. 2013. “Wetlands, Carbon, and Climate Change”. Landscape Ecol 28:583-597. https://doi.org/10.1007/s10980-012-9758-8.

Moomaw, W. R., Chmura, G. L., Davies, G. T., Finlayson, C. M., Middleton, B. A., Natali, S. M., Sutton-Grier, A. E. 2018. “Wetlands in a Changing Climate: Science, Policy and Management.” Wetlands, 38(2), 183-205). https://doi.org/10.1007/s13157-018-1023-8.

Moore, C. 2017. “Turning Up the Heat: Urban Heat Islands in Snohomish County.” Master's Thesis, University of Washington. http://hdl.handle.net/1773/39183.

Municipal Research and Services Center; “Local Government Climate Change Documents.” https://mrsc.org/explore-topics/environment/sustainability/climate-change-documents.

Myrick, Sonia. “Synthetic Sports Fields and the Heat Island Effect | Operations | Parks and Recreation Magazine | NRPA.” National Recreation and Parks Association. https://www.nrpa.org/parks-recreation-magazine/2019/may/synthetic-sports-fields-and-the-heat-island-effect/.

Nahlik, A. M. and Fennessy, M.S. 2016. “Carbon Storage in US Wetlands.” Nature Communications, 7 (13835). https://www.nature.com/articles/ncomms13835.

National Oceanic Atmospheric Association. 2020, “National Weather Service Advanced Hydrologic Prediction Service.” https://water.weather.gov/ahps2/river.php?wfo=sew&wfoid=18678&riverid=203922&pt%5B%5D=143057&pt%5B%5D=147767&allpoints=141567%2C143057%2C155328%2C142761%2C147767%2C155032&data%5B%5D=crests.

National Oceanic Atmospheric Association. 2023 “Heat Safety.” NOAA’s National Weather Service. https://www.weather.gov/grb/heat.

Nowak, D. J., E. J. Greenfield, R. E. Hoehn, and E. Lapoint. 2013. “Carbon Storage and Sequestration by Trees in Urban and Community Areas of the United States.” Environmental Pollution 178:229–236. https://www.fs.usda.gov/nrs/pubs/jrnl/2013/nrs_2013_nowak_001.pdf.

Office of the Washington State Climatologist “PNW Temperature, Precipitation, and SWE Trend Analysis Tool.” https://climate.washington.edu/climate-data/trendanalysisapp/.

Puget Sound Clean Air Agency; “Priorities.” Accessed May 10, 2023. https://www.pscleanair.gov/31/Priorities.

Puget Sound Regional Council. 2020. “Vision 2050: A Plan for the Central Puget Sound Region.” https://www.psrc.org/planning-2050/vision-205.

Puget Sound Regional Council. 2021. “Regional Economic Strategy.” https://www.psrc.org/media/1688.

Raymond, C., M. Rogers. 2022. “Climate Mapping for a Resilient Washington.” Accessed April 12, 2022. Prepared by the Climate Impacts Group, University of Washington, Seattle and Research Data & Computing Services, University of Idaho, Moscow. https://cig.uw.edu/resources/analysis-tools/climate-mapping-for-a-resilient-washington/.

Reid, C.E., Brauer, M., Johnston, F.H., Jerrett, M., Balmes, J.R. and Elliott, C.T., 2016. “Critical review of health impacts of wildfire smoke exposure”. Environmental health perspectives, Vol 124, 9,1334-1343. https://ehp.niehs.nih.gov/doi/full/10.1289/ehp.1409277

Risk Factor. n.d. “Snohomish, Washington Flood Factor Report.” https://riskfactor.com/city/snohomish-wa/5365170_fsid/flood.

Roy, S., Roy, R., Passalacqua, C. 2021. “Equity-Based Community Greening Program Task 1.5 – Urban Heat Island Assessment,” Weston and Sampson.

Science Based Targets Network. 2020. “Science-Based Climate Targets: A Guide for Cities.”https://sciencebasedtargetsnetwork.org/wp-content/uploads/2020/11/SBTs-for-cities-guide-nov-2020.pdf.

Stanford University's Environmental Change and Human Outcomes Lab, NPR's California Newsroom. 2021. "Dangerous Air: We Mapped The Rise In Wildfire Smoke Across America." CapRadio, National Public Radio.

Snohomish County. 2013. "Sustainable Operations Action Plan for County Operations." https://snohomishcountywa.gov/DocumentCenter/View/9214/Sustainable-Operations-Action-Plan?bidId=.

Snohomish County. 2018. "Greenhouse Gas Emissions Inventory for Government Operations." https://snohomishcountywa.gov/DocumentCenter/View/78473/Snohomish_2018_LGO_Inventory_FINAL?bidId= .

Snohomish County. 2019. "Snohomish County Emergency Management Plan." https://snohomishcountywa.gov/2244/Sno-Co-CEMP#:~:text=Snohomish%20County%20.

Snohomish County. 2020. "Hazard Mitigation Plan." https://snohomishcountywa.gov/2429/74425/Hazard-Mitigation-Plan.

Snohomish County. 2021. "Countywide Planning Policies for Snohomish County - Appendix B: Growth Targets." https://snohomish.county.codes/CPP/AxB.

Snohomish County. 2022. "Snohomish County Communitywide Geographic GreenhouseGas Emissions." https://www.snohomishcountywa.gov/DocumentCenter/View/106055/GHG-Emiss-Inventory-SC19-00-03_GeoEmissionsReport?bidId=.

Snohomish County. 2022. "Snohomish County Comprehensive Plan - Population and Employment Element Draft." https://www.snohomishcountywa.gov/DocumentCenter/View/107079/Draft_Pop_Emp_Attachment-A---Narrative_Mar-8-2023#:~:text=December%202022%20OFM%20population%20projections,at%20the%20county%20level%20only.

Snohomish County Public Works. 2003. "State of the Lakes Report: Blackman Lake." https://snohomishcountywa.gov/DocumentCenter/View/62589/blackman#:~:text=acres%20and%20is%20r.

Snohomish County Public Works. 2010. "Flood Hazard Management Issues in Snohomish County." https://www.snohomishcountywa.gov/DocumentCenter/View/6699/Flood-Hazard-Management-Issues-in-Snohomish-County?bidId=

The Intergovernmental Panel on Climate Change (IPCC). 2023. "Synthesis Report of the IPCC Sixth Assessment Report (AR6) Summary for Policymakers. (AR6)." https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_SPM.pdf

The Nature Conservancy. 2023. Resilient Land Mapping Tool. Accessed May 10, 2023.

https://maps.tnc.org/resilientland/.

The Watershed Company. 2018. “PORTfolio Carbon Sequestration Assessment.” Prepared on behalf of the Port of Seattle (POS). Reference Number: 160246.3. No DOI; provided by POS.

Toming, Kaire; Kotta, Jonne; Uuemaa, Evelyn; Sobek, Sebastian; Kutser, Tiit; Tranvik, Lars J. 2020. “Predicted Lake Dissolved Organic Carbon at a Global Scale..” https://zenodo.org/record/3452124#.ZGJFFHbMJdh.

United States Census Bureau. 2000. “Census Bureau Data - Population.” Accessed June 2, 2023. https://data.census.gov/profile?g=160XX00US5365170.

United States Census Bureau. 2000. “Census Bureau Data - Employment.” Accessed June 2, 2023. https://data.census.gov/profile?g=160XX00US5365170.

United States Census Bureau. 2010. “Census Bureau Data - Population.” Accessed June 2, 2023. https://data.census.gov/profile?g=160XX00US5365170.

United States Census Bureau. 2010. “Census Bureau Data - Employment.” Accessed June 2, 2023. https://data.census.gov/profile?g=160XX00US5365170.

United States Census Bureau. 2020. “Census Bureau Data - Population.” Accessed June 2, 2023. https://data.census.gov/profile?g=160XX00US5365170.

United States Census Bureau. 2020. “Census Bureau Data - Employment.” Accessed June 2, 2023. https://data.census.gov/profile?g=160XX00US5365170.

United States Environmental Protection Agency. 2017. “Climate Impacts on Human Health.” Accessed April 12, 2023. https://19january2017snapshot.epa.gov/climate-impacts/climate-impacts-human-health_.html#Populations%20of%20concern.

United States Environmental Protection Agency. 2022. “FY 2022-2026 EPA Strategic Plan.” https://www.epa.gov/planandbudget/strategicplan.

United States Environmental Protection Agency. 2023. “Environmental Justice”. Accessed May 24, 2023. https://www.epa.gov/environmentaljustice.

United States Environmental Protection Agency Center for Corporate Climate Leadership. 2014. “Greenhouse Gas Inventory Guidance: Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases.” https://www.epa.gov/sites/default/files/2015-07/documents/fugitiveemissions.pdf.

United States Environmental Protection Agency Center for Corporate Climate Leadership. 2022. “Emission Factors for Greenhouse Gas Inventories.” Accessed June 2, 2023. https://www.epa.gov/system/files/documents/2022-04/ghg_emission_factors_hub.pdf.

United States Census Bureau. 2020. American Community Survey 5-Year Estimates. https://data.census.gov/advanced.

United States Geological Survey. 2019. "Landsat 8 (L8) Data Users Handbook." https://d9-wret.s3.us-west-2.amazonaws.com/assets/palladium/production/s3fs-public/atoms/files/LSDS-1574_L8_Data_Users_Handbook-v5.0.pdf.

Valach AC, Kasak K, Hemes KS, Anthony TL, Dronova I, Taddeo S, Silver WL, Szutu D, Verfaillie J, Baldocchi DD. 2021. "Productive Wetlands Restored for Carbon Sequestration Quickly Become Net CO_2 Sinks with Site-Level Factors Driving Uptake Variability." PLoS One. 2021 Mar 25;16(3):e0248398. DOI: 10.1371/journal.pone.0248398. PMID: 33765085; PMCID: PMC7993764.

Washington State Department of Commerce. 2023. "Model Climate Element Draft." https://deptofcommerce.app.box.com/s/bfxuex8uvupyeh7hsfdnlhkpduqgg1cj.

Washington State Department of Ecology. 2021. "2020-2021 Washington Statewide Waste Characterization Study." https://apps.ecology.wa.gov/publications/documents/2107026.pdf.

Washington State Department of Ecology. 2022. Water Quality Atlas Map Viewer. https://apps.ecology.wa.gov/waterqualityatlas/wqa/map

Washington State Department of Ecology. 2023. "Washington Cap-and-Invest Program Auction #1 February 2023 Summary Report." https://apps.ecology.wa.gov/publications/documents/2302022.pdf

Washington State Department of Health. 2021. "Heat Wave 2021." https://doh.wa.gov/emergencies/be-prepared-be-safe/severe-weather-and-natural-disasters/hot-weather-safety/heat-wave-2021

Washington State Legislature. Shoreline Management Act, Chapter 90.58, 42nd Legislature. (1971).

Washington State Legislature. Clean Energy - Electric Utilities - Various Provisions, H.R. 5116, 66th Legislature. (2019).

Washington State Legislature. Greenhouse Gas Emissions Limits - Amendment, H.R. 2311, 66th Legislature. (2020).

Washington State Legislature. Greenhouse Gas Emissions - Cap and Invest Program, S. 5126, 67th Legislature. (2021).

Washington State Legislature. Climate Change Planning, H.R. 1181, 68th Legislature. (2023).

Williams, C.A., N. Hasler, H. Gu, and Y. Zhou. 2020. "Forest Carbon Stocks and Fluxes from the NFCMS, Conterminous USA, 1990-2010." ORNL DAAC, Oak Ridge, Tennessee, USA. https://doi.org/10.3334/ORNLDAAC/1829.

Yasarer, Lindsay. 2015. “Estimating the Carbon Footprint of Lakes and Reservoirs.” North American Lake Management Society. https://www.nalms.org/wp-content/uploads/LakeLine/35-3/Articles/35-3-5.pdf.

Zhu, Zhiliang, ed., Bergamaschi, Brian, Bernknopf, Richard, Clow, David, Dye, Dennis, Faulkner, Stephen, Forney, William, Gleason, Robert, Hawbaker, Todd, Liu, Jinxun, Liu, Shuguang, Prisley, Stephen, Reed, Bradley, Reeves, Matthew, Rollins, Matthew, Sleeter, Benjamin, Sohl, Terry, Stackpoole, Sarah, Stehman, Stephen, Striegl, Robert, Wein, Anne, and Zhu, Zhiliang. 2010. “A Method for Assessing Carbon Stocks, Carbon Sequestration, and Greenhouse-Gas Fluxes in Ecosystems of the United States Under Present Conditions and Future Scenarios”: U.S. Geological Survey Scientific Investigations Report 2010–5233, 188 p. http://pubs.usgs.gov/sir/2010/5233/.

Appendices

Appendix A: 2022 City of Snohomish GHG Inventory Data

Please see the Excel attachment titled “Appendix A_2022 City of Snohomish GHG Inventory Data”

Appendix B: Snohomish Climate Projections

Please see the Excel attachment titled “Appendix B_Snohomish Climate Projections”

Appendix C: Risk Matrix for the City of Snohomish

Please see the Excel attachment titled “Appendix C_Risk Matrix for the City of Snohomish”

Appendix D: Regulation Summaries

Please see the Excel attachment titled “Appendix D_Regulation Summaries”

Appendix E: Snohomish County Hazard Mitigation Plan Climate Change Summary

Please see the Excel attachment titled “Appendix E_Snohomish County Hazard Mitigation Plan Climate Change Summary”

Appendix F: Comprehensive Policy Menu

Please see the Excel attachment titled “Appendix F_Comprehensive Policy Menu”

Appendix G: Tailored Policy Menu

Please see the Excel attachment titled “Appendix G_Tailored Policy Menu”

Appendix H: Climate Resilience Advisory Board Meeting Summary

Please see following page

Appendix H: Climate Resilience Advisory Board Meeting Summary
May 18, 2023 5:00-7:00 pm
Snohomish Library

Attendees:
City of Snohomish: Brady Begin and Brooke Eidem;
Climate Resilience Advisory Board: Alaksandar Babic, Marie Blakey, Elle Holtz, Leslie Indresand, and Michelle Madejski;
University of Washington (UW): Keala Aronowitz, Matthew Bauman, Scott Brabec, Carson Bridges, Neha Chinwalla, Amy Miller, Caroline Passalacqua, Catherine Schmidt, Tim Seed, and Arlyn Purcell (Professor)

On May 18, 2023, UW students presented to the City of Snohomish's Climate Resilience Advisory Board (CRAB) to share goals and objectives of the project, the completed work to date, and next steps. This included a review of climate impacts to the City of Snohomish, a greenhouse gas emissions overview, identification of and projections related to potential hazards, and review of the SWOT analysis. Throughout the meeting, CRAB members used large maps of Snohomish, post-its, and markers to record their thoughts about the community's assets and their valuable insights concerning potential hazards to the City including heat, drought, wildfire smoke, precipitation, and flooding. Students took questions from CRAB members and City representatives. Community input will be used to cross-check work to date with this narrative as well as in the process of determining policy recommendations.

Students asked the following questions as prompts and received respective feedback from CRAB members verbatim:

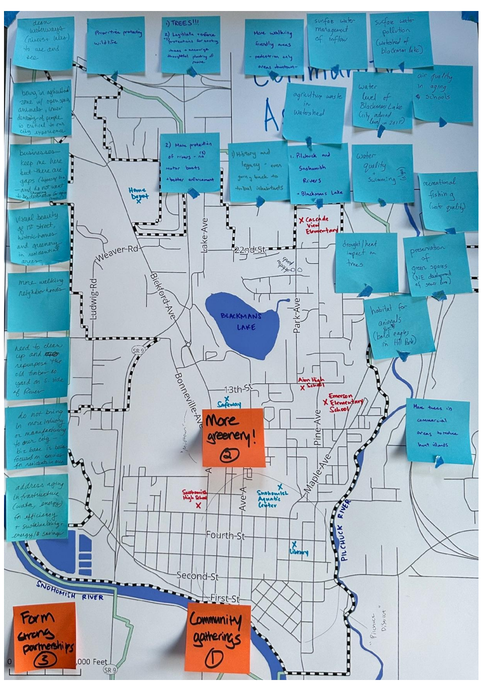
Community Assets

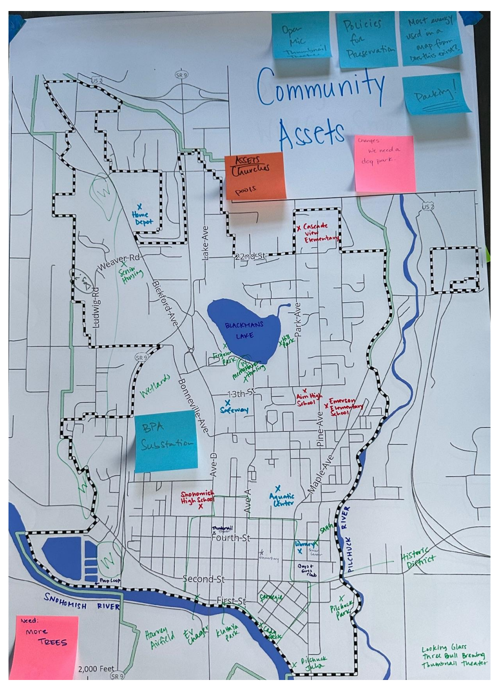
- **What is important to you in Snohomish?**
  Historic District, Churches, Pools, Wetlands, SAHG, Library, Senior Center, Senior housing, Merry Haren Housing, Boys & Girls Club, Pilchuck park, Cady Park, Klahaya Park, Hill Park, Ferguson Park, EV Charger, Harrey Field, Detention ponds, Pilchuck District, Community gatherings, Open mic at Thumbnail Theater, Looking Glass, Three Bull Brewing, Trees, Farms, All wildlife - not just salmon, History and legacy - even going back to tribal inhabitants, Pilchuck and Snohomish Rivers, Being in agricultural zone with open space, animals, lower density of people is critical to our city experience, Businesses keep me here but there are gaps (types of business) - and I do not want to be shopping destination for region (traffic!), Visual beauty of First Street, Historic homes and greenery in residential areas

- **Are there any changes you would like to see in Snohomish as it relates to the environment?**

We need a dog park, Parking, Need more trees, Trees and plants, More greenery in Midtown, Legislate and enforce, More walking-friendly areas/pedestrian only areas downtown, More walking neighborhoods, Air quality, Air quality in aging schools, Agriculture waste in watershed, More protection of rivers, Water quality and swimming (algae), Recreational fishing (water quality)

- **What would you do to protect the places/people/things in Snohomish that are important to you?**
  Form strong partnerships, Policies for preservation, Preservation of green spaces (NE development of sewer line), Protections for existing trees and encourage thoughtful planting of more, Drought/heat impact on trees, More trees in commercial areas to reduce heat islands, More rain gardens and help for homeowners to put them in, Surface water management of inflow, Surface water pollution (watershed of Blackmans Lake), Water level in Blackmans Lake (city reviewed in 2015), Prioritize protecting wildlife, No motor boats and better enforcement, Habitat for animals (bald eagles in Hill Park), Clean waterways (rivers and lakes) to use and see, Need to clean up and repurpose the old timber company yard on South side of river, Do not bring in more industry and manufacturing in our city - business base is better focused on services for residents in the area, Address aging infrastructure (water, energy) for efficiency and sustainability and energy/$ savings, Incentives for homeowners to get solar panels, electric cars, etc.





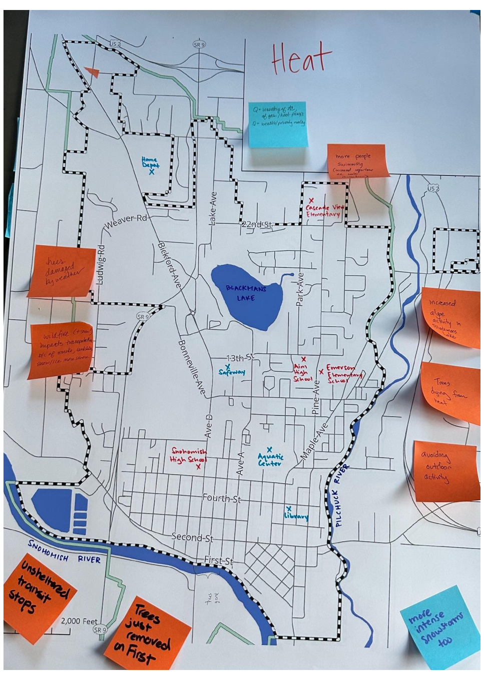
Heat

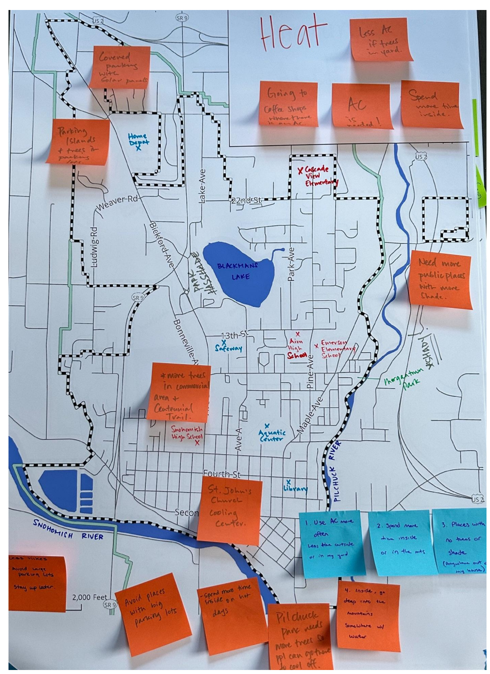
- **How have changes in seasonal temperatures affected you?**
  AC is needed, More people swimming (increased importance on water recreation), Trees dying from heat, Trees were just removed on First St., Avoiding outdoor activity, More intense snowstorms too, Wildfire and snow impacts transportation because of smoke, landslides, snow/ice more severe

- **How has hotter weather affected your summer activities?**
  Spend more time inside, Go to coffee shops where there is an AC, Increased algae activity in Blackmans Lake, We use less AC if there are trees in the yard, Need more public places with more shade, More trees in commercial area and Centennial Trail

- **What areas in the city do you avoid on hot days?**
  Spend more time inside on hot days, Avoid places with big parking lots, Parking islands and trees in parking lots, Less hikes, Stay up later, Unsheltered transit stops, Need covered parking with solar panels on top

- **Where do you go to cool off on a hot day?**
  Morgantown Park because of the shade, Blackmans Lake Park has shade, Stay inside, Deep into the mountains, Somewhere with water, St. John's cooling center



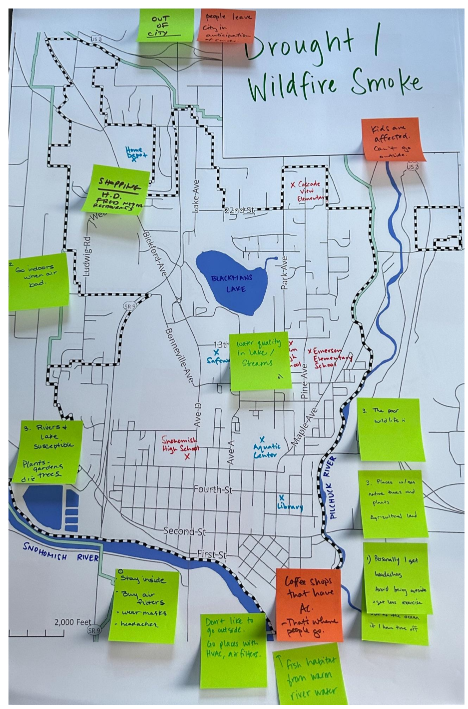


Drought/Wildfire Smoke

- **How have you been impacted by smoke days?**
  Kids are affected - can’t go outside, Schools affected - indoor recess, Headaches, Avoid being outside, Avoid leaving house, Stay inside, Hide in my house, Need to keep windows closed, but too hot, Get less exercise, Buy air filters, Wear masks, Reuse N-95s from Covid to breathe, Water quality in lake and streams, It was worse than people expected, Employee safety: what do you do if you can’t work remotely?, Smoke was worse in some places than others

- **Where do people in Snohomish go to get relief from poor air quality?**
  Spaces with AC and air filters, Coffee shops that have AC, Don’t go outside; they go indoors to places with HVAC and air filters, People leave the city in anticipation of smoke, Out to the ocean if I have time off, Shopping - Home Depot, Fred Meyer, restaurants, Pilchuck River - many pockets; go with grandchildren, free, outside

- **Where do you think is especially susceptible to drought?**
  Places with non-native trees and plants, Agricultural land, Rivers and lake are susceptible, Blackmans Lake water, recreational access (drought), The poor wildlife, Fish habitat from warm river water, Need more green park spaces with trees



Precipitation/Flooding

- **What changes have you noticed in flooding in recent years?**
  River erosion, Residential flooding (inadequate flow for stormwater), Health concerns of flooding, WW treatment plant, People driving around barriers - danger - human behavior,

- **What places in the city regularly flood? Has the extent of flooding increased?**
  [Note locations on map], Low-lying areas, Riverfront Trail, Lincoln Ave South of First St., "Porch community" - buildings from the 1800s, Road flooding by fields, Will railroad tracks flood at some point?

- **What do you think should be done to reduce flooding?**
  Old Rules: floodplain regulations, stormwater regulations, Strict regulations for hard surfaces, Micro-electric systems, Better drainage on all roads, More rain gardens, More plantings, Plant more trees, Green roofs, Stormwater park along waterfront near First St. (see map pic), Streams need clearing